

# Microwaves & RF

THE HIGH SPEED ELECTRONICS GROUP

## News

ARMMS meeting  
reviews 3G testing

## Design Feature

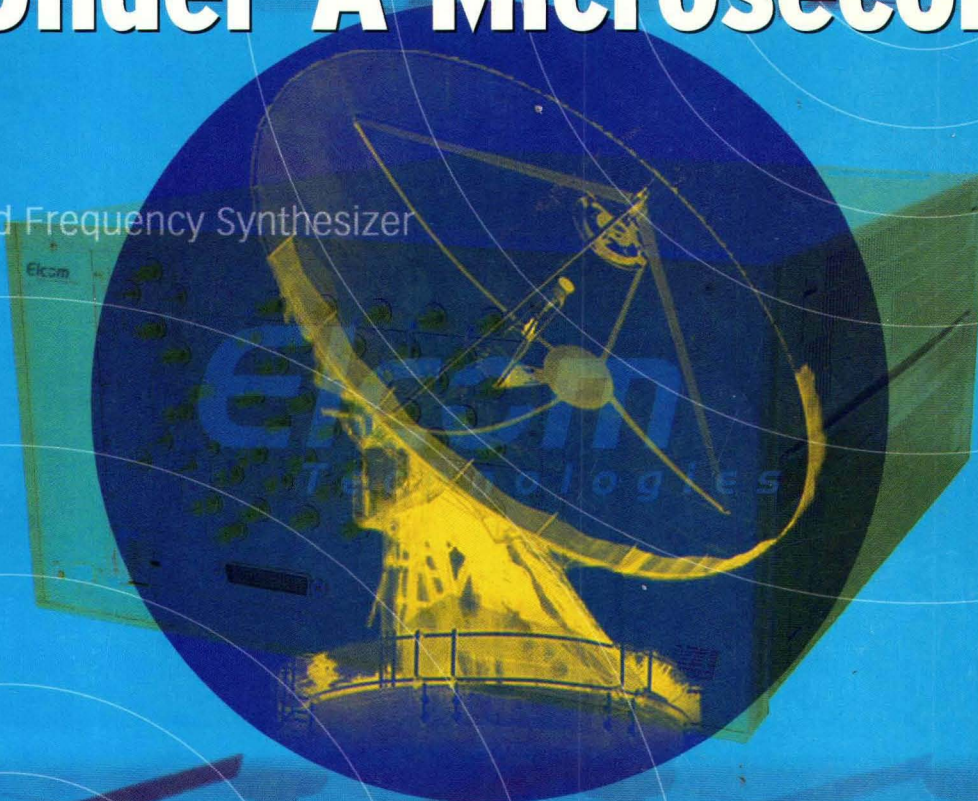
Setting bias points  
for linear RF PAs

## Product Technology

Software defines  
surveillance receiver

# Synthesizers Switch In Under A Microsecond

Broadband Frequency Synthesizer



#BXNPGNX \*\*\*\*\*AUTO\*\*3-DIGIT 543  
#533579017 5 # RF 002 100 SCK 778



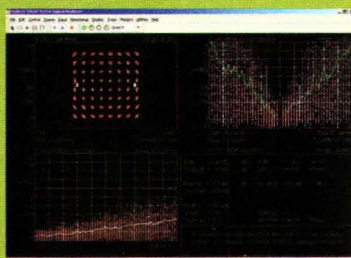
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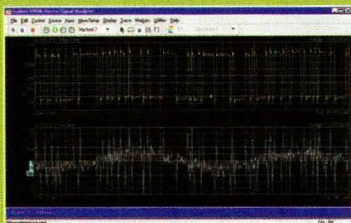
**Military  
Electronics  
Issue**

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BLUETOOTH & WLAN:  
ACCELERATING  
THE DRIVE TO MARKET  
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For this IEEE 802.11a signal, the overall EVM measurement is acceptable but viewing EVM versus time (lower left) and channel (upper right) shows the effect of a timing error.



The FSK error display can highlight the effects of unwanted frequency modulation, which may indicate the presence of spurious signals in the modulator.

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The original idea was simple: use wireless links to give the wired generation more mobility. Of course, turning *Bluetooth* and *Wi-Fi* into reality—without much time for analysis—has been anything but simple. Perhaps we can help.

**Enhancing interoperability.** Many people attribute *Wi-Fi*'s popularity to *WECA* testing that certifies device interoperability. Those who've passed tell us the roots of success often reach back to early tweaks in their transmitter or receiver designs. For transmitters, error vector magnitude (EVM) versus time or channel is a measure of modulation quality that can highlight underlying problems such as nonlinear distortion, phase noise and spurious signals. Conversely, making receivers more forgiving of nonideal transmitters can come from testing with impaired signals—in hardware, simulation or a system that links both.

**Achieving certification.** The Agilent Interoperability Certification Labs and Agilent's network of test partners are ready to help, too: they've tested hundreds of *Wi-Fi* devices and can help you clear the qualification hurdle.

To learn more, please visit [www.agilent.com/find/wn](http://www.agilent.com/find/wn), where you can request a FREE CD-ROM packed with articles, solution guides, and application notes such as "RF Testing of Wireless LAN Products" and "Verifying Bluetooth Baseband Signals."



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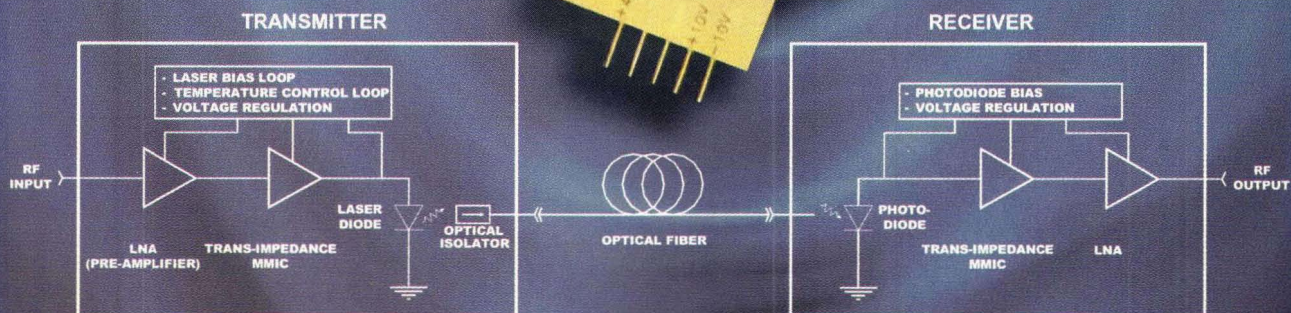
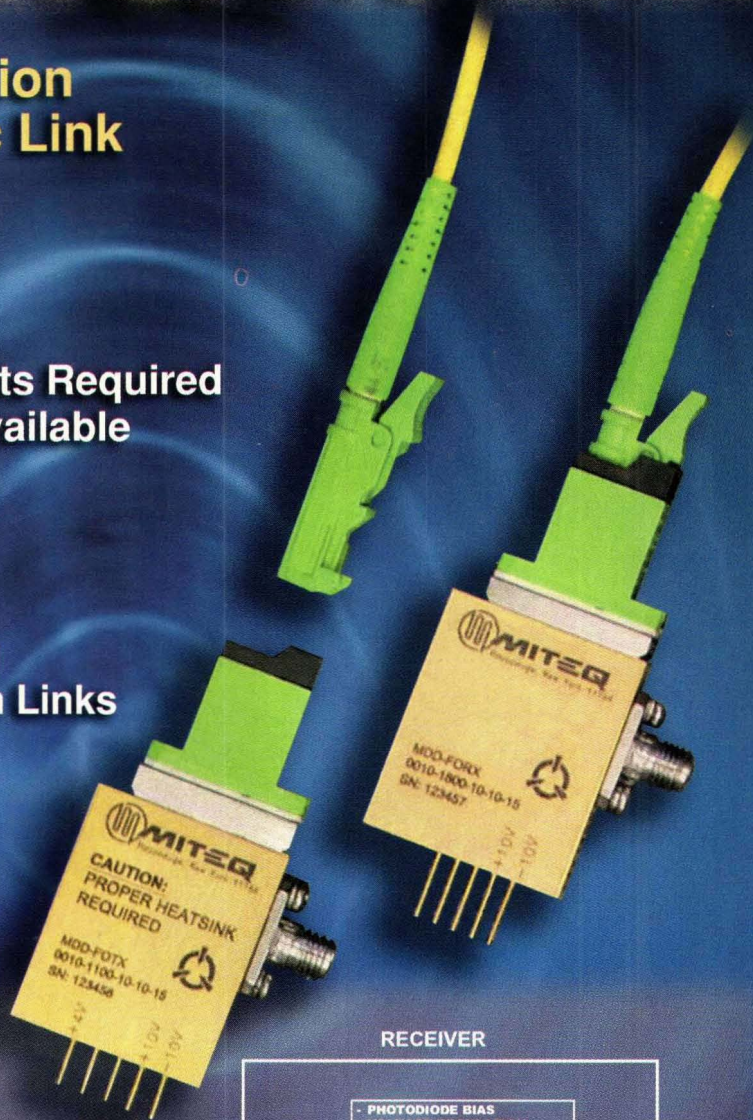
# MDD FIBER OPTIC LINK

## 11 GHz Direct Modulation Microwave Fiber Optic Link

- Small Size
- Bandwidth to 11 GHz
- Low Noise Figure
- Plug-In Optical Connector
- No External Control Circuits Required
- Custom Configurations Available

### Applications Include:

- Antenna Remoting
- Local Oscillator Remoting
- Interfacility Communication Links
- Aircraft and Shipboard



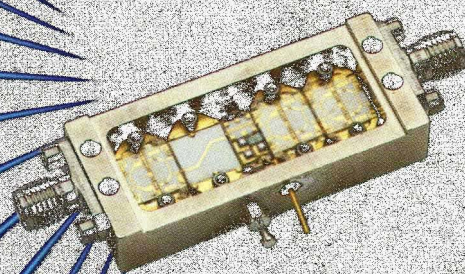
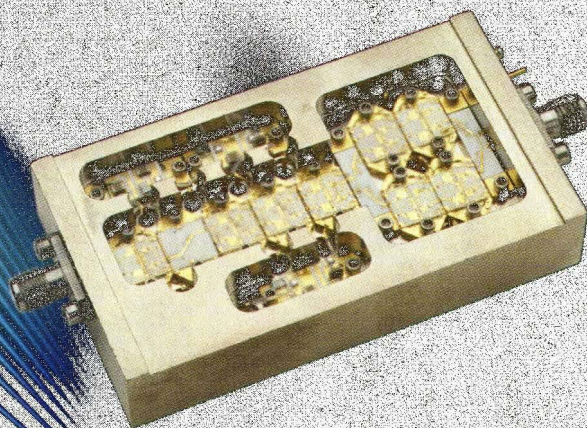
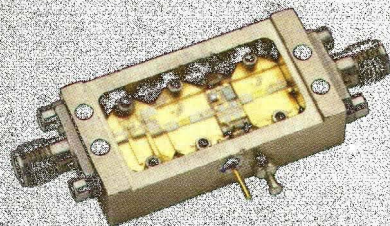
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## ULTRA BROAD BAND

Model	Freq. Range GHz	Gain dB min	NF dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA018-203	0.5-18.0	20	5.0	2.5	7	17	2.0:1	250
JCA018-204	0.5-18.0	25	4.0	2.5	10	20	2.0:1	300
JCA218-506	2.0-18.0	35	5.0	2.5	15	25	2.0:1	400
JCA218-507	2.0-18.0	35	5.0	2.5	18	28	2.0:1	450
<b>JCA218-407</b>	2.0-18.0	30	5.0	2.5	<b>21</b>	31	2.0:1	500

## MULTI OCTAVE AMPLIFIERS

Model	Freq. Range GHz	Gain dB min	NF dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA04-403	0.5-4.0	27	5.0	1.5	17	27	2.0:1	550
JCA08-417	0.5-8.0	32	4.5	1.5	17	27	2.0:1	550
JCA28-305	2.0-8.0	22	5.0	1.0	20	30	2.0:1	550
JCA212-603	2.0-12.0	32	5.0	3.0	14	24	2.0:1	550
JCA518-406	6.0-18.0	20	6.0	2.0	25	35	2.0:1	600
JCA518-507	6.0-18.0	25	6.0	2.0	27	37	2.0:1	800

## MEDIUM POWER AMPLIFIERS

Model	Freq. Range GHz	Gain dB min	NF dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-P01	1.35-1.85	35	4.0	1.0	33	41	2.0:1	1000
JCA34-P02	3.1-3.5	40	4.5	1.0	37	45	2.0:1	2200
JCA56-P01	5.9-6.4	30	5.0	1.0	34	42	2.0:1	1200
JCA812-P03	8.0-12.0	40	5.0	1.5	33	40	2.0:1	1700
JCA1218-P02	12.0-18.0	22	4.0	2.0	25	35	2.0:1	700

## LOW NOISE OCTAVE BAND LNA'S

Model	Freq. Range GHz	Gain dB min	NF dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-3001	1.0-2.0	40	0.8	1.0	10	20	2.0:1	200
JCA24-3001	2.0-4.0	32	1.2	1.0	10	20	2.0:1	200
JCA48-3001	4.0-8.0	40	1.3	1.0	10	20	2.0:1	200
JCA812-3001	8.0-12.0	32	1.8	1.0	10	20	2.0:1	200
JCA1218-600	12.0-18.0	45	2.0	1.0	10	20	2.0:1	250

## NARROW BAND LNA'S

Model	Freq. Range GHz	Gain dB min	NF dB max	Gain Flat +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-1000	1.2-1.6	35	0.75	0.5	10	20	2.0:1	80
JCA28-302	2.2-2.3	30	0.8	0.5	10	20	2.0:1	80
JCA34-301	3.7-4.2	30	1.0	0.5	10	20	2.0:1	90
JCA56-401	5.4-5.9	40	1.0	0.5	10	20	2.0:1	120
JCA78-300	7.25-7.75	27	1.2	0.5	13	23	2.0:1	120
JCA910-300	9.0-9.5	25	1.2	0.5	13	23	1.5:1	150
JCA910-3001	9.5-10.0	25	1.2	0.5	13	23	1.5:1	150
JCA1112-300	11.7-12.2	27	1.1	0.5	13	23	1.5:1	150
JCA1213-3001	12.2-12.7	25	1.1	0.5	10	20	2.0:1	200
JCA1415-3001	14.4-15.4	35	1.4	1.0	14	24	2.0:1	200
JCA1819-3001	18.1-18.6	25	1.5	0.5	10	20	2.0:1	200
JCA2021-3001	20.2-21.2	25	2.5	0.5	10	20	2.0:1	200

### Features:

- Removable SMA Connectors
- Competitive Pricing
- Compact Size

### Options:

- Alternate Gain, Noise, Power, VSWR levels if required
- Temperature Compensation
- Gain Control

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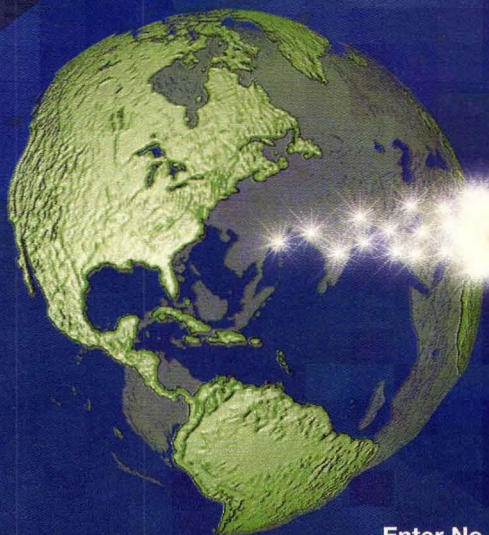
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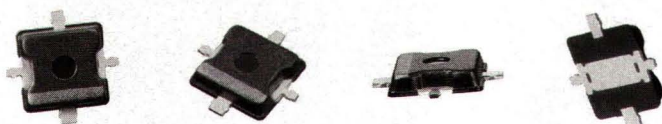
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## 0.5 – 3W DEVICES

### For Fixed Wireless Access



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- Large grounding pad for efficient heat dissipation

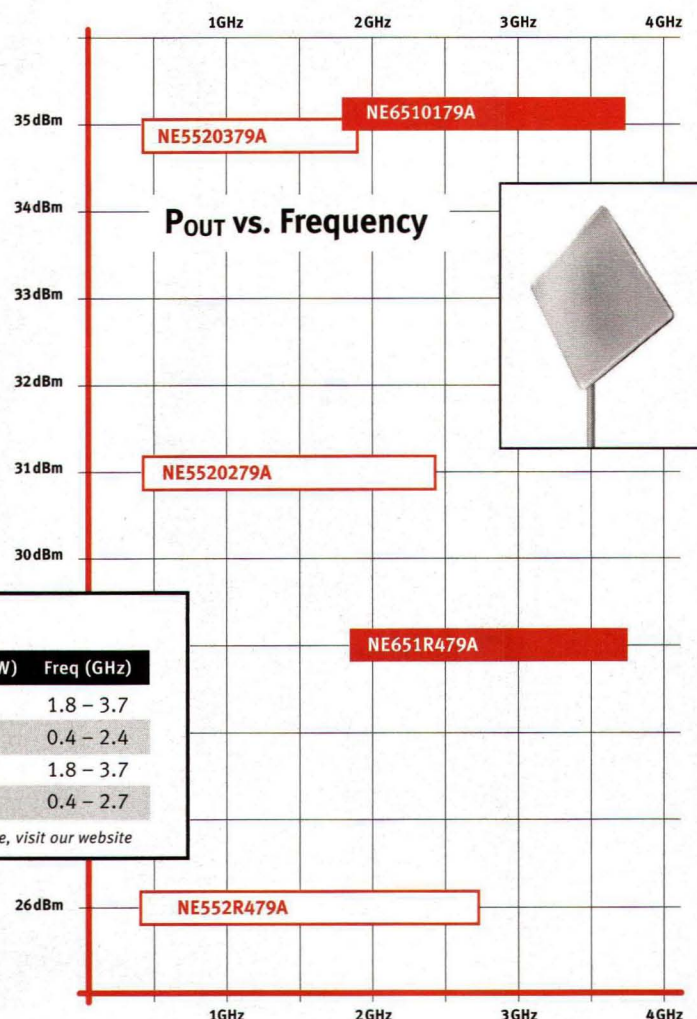
#### New Medium Power GaAs & LDMOS FETs

- High output power, high linear gain and high efficiency.
- Low thermal resistance lets you drive your designs harder for higher linearity.
- Low voltage operation and miniature size make these devices ideal for wireless modems, wireless LANs, mobile radios, cordless phones, cellular phones pagers, and other handheld designs.

#### Typical Performance @ 2.3GHz, $V_{DD} = 5V$

Part Number	Type	$P_{1dB}$ (dBm)	$G_L$ (dB)	$R_{TH}$ (°C/W)	Freq (GHz)
NE6510179A	GaAs	35	11	5	1.8 – 3.7
NE5520279A	LDMOS	31	10	7	0.4 – 2.4
NE651R479A	GaAs	29	12	12	1.8 – 3.7
NE552R479A	LDMOS	26	11	10	0.4 – 2.7

\*Other devices available, visit our website



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# Microwaves & RF

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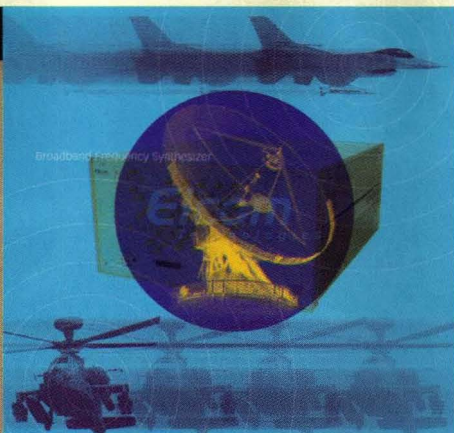
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## COVER STORY

### 98 Synthesizers Offer Submicrosecond Switching

A series of broadband frequency synthesizers provides very low phase noise with submicrosecond switching time for military applications.



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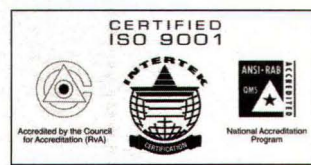
- Multi-path attenuation/switching schemes
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- Specialized testing and calibration
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- Rack mounted chassis designs.

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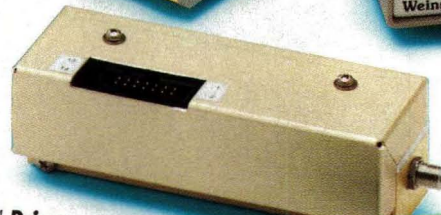
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- Internal non-volatile memory to store device parameters such as serial number, cell dB values, relay configurations, and switching requirements.
- Custom Designs, Our Specialty!

MODEL	ATTEN RNG/ STEP (dB)	FREQ RNG (GHz)	NO. CELLS
150T-11	0-11/1	dc-18 GHz	4
150T-15	0-15/15		4
150T-31	0-31/1		5
150T-62	0-62/2		5
150T-70	0-70/10		3
150T-75	0-75/5	dc-4 GHz	4
150T-110	0-110/10		4
151T-11	0-11/1		4
151T-15	0-15/15		4
151T-31	0-31/1		5
151T-62	0-62/2		5
151T-70	0-70/10		3
151T-75	0-75/5	dc-26.5	4
151T-110	0-110/10		4
152T-11	0-11/1		4
152T-15	0-15/1		4
152T-55	0-55/5		4
152T-90	0-90/10		4
3200T-1	0-127/1	dc-2*	8
3200T-2	0-63.75/0.25		8
3201T-1	0-31/1		5
3201T-2	0-120/10		5

\*Other 2 & 3 GHz models available.



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Specific Driver Configurations can be designed for operating your electromechanical devices or retrofitting an existing device with the SmartStep™ Approach.

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- Provides a flexible, powerful, low cost solution for the bus control of programmable step attenuators and other electromechanical devices under computer bus control.
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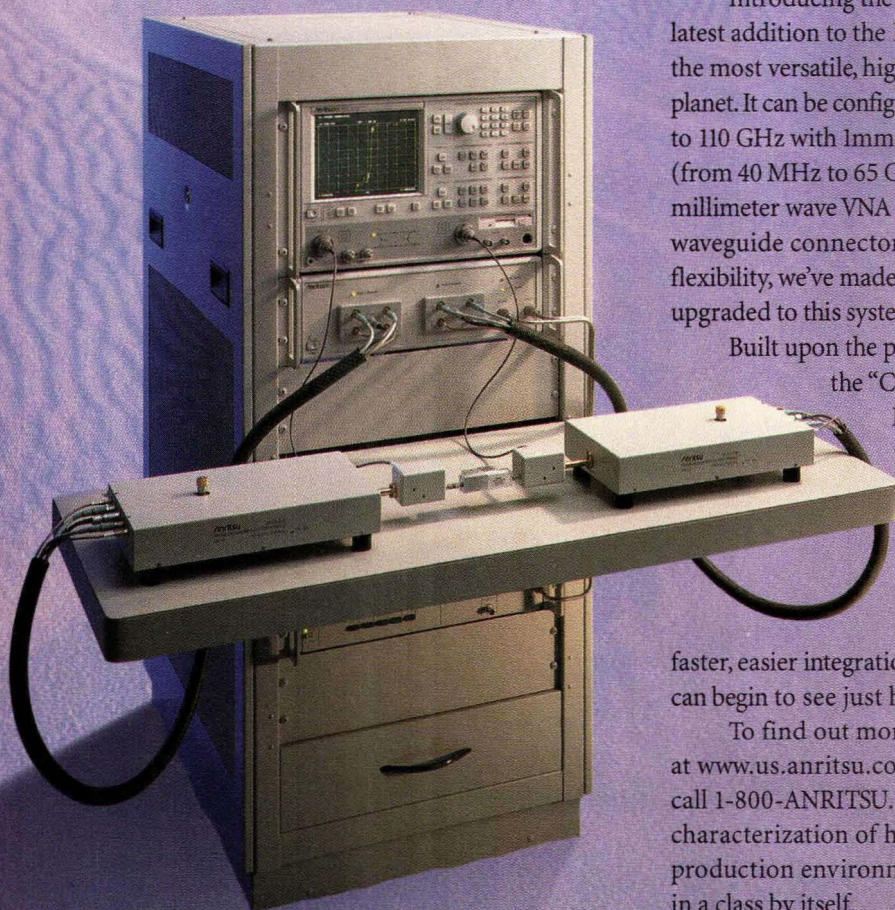


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### ME7808A Lightning Broadband VNA

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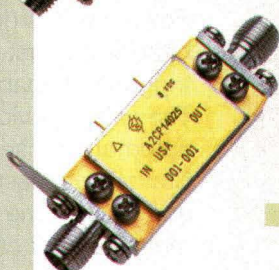
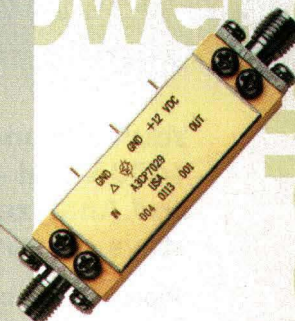
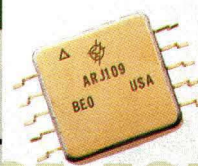
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These high-performance amplifiers cover frequencies from 500 kHz to 14 GHz, and offer output powers from 200 to 500 Milliwatts.

Model	Freq. Range (MHz)	Small Signal Gain (dB) Typ.	Noise Figure (dB) Typ.	Power Output at 1dB Comp. (dBm) Typ.	Intercept Point 3rd/2nd (dBm) Typ.	D.C. Volts Nom.	D.C. mA Typ.
ARJ109	0.5-200	10.8	4.5	28.5	44/75	15	235
AP448	10-400	10.5	4.3	24.8	42/53	15	110
AP1309	10-1300	12.5	2.5	23.0	36/49	15	100
AP2009	10-2000	11.0	3.5	28.0	40/50	15	188
AP3509	100-3500	8.5	5.5	27.0	38/48	15	190
A2CP5008	2000-5000	12.0	3.0	24.5	35/50	12	250
A3CP7029	3000-7000	28.0	3.3	27.5	35/55	12	425
A2CP14025	8000-14000	17.0	5.5	27.0	36/54	8	325

Specifications are typical.



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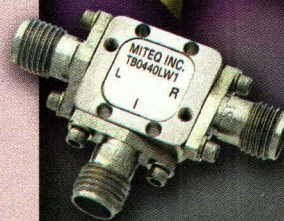
# MILLIMETER WAVE MIXER ASSEMBLIES

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## MIXERS

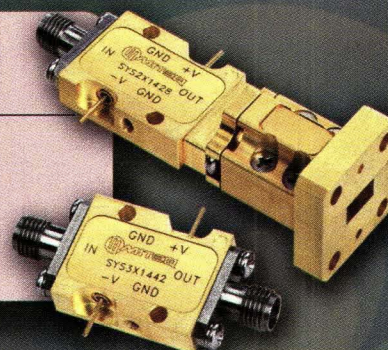
Model Number	Frequency (GHz)			LO Power (dBm)	Conversion Loss (dB Typ.)	LO-RF Isolation (dB, Typ.)
	RF	LO	IF			
TB0440LW1	4-40	4-42	.5-20	10-15	10	20
DB0440LW1	4-40	4-40	DC-2	10-15	9	25
SBE0440LW1	4-40	2-20**	DC-1.5	10-15	10	20
IR2640L17*	26-40	26-40	Note 1	15	10	15
M2640W1	26-40	26-40	DC-12	10-12	10	20
TB2640LW1	26-40	26-40	.5-20	10-15	10	20

\* Image Rejection typically 15 dB. \*\* Sub Harmonic  
Note 1: IF Option A: 20-40 MHz, B: 40-80 MHz, C: 100-200 MHz, Q: DC-1000 MHz

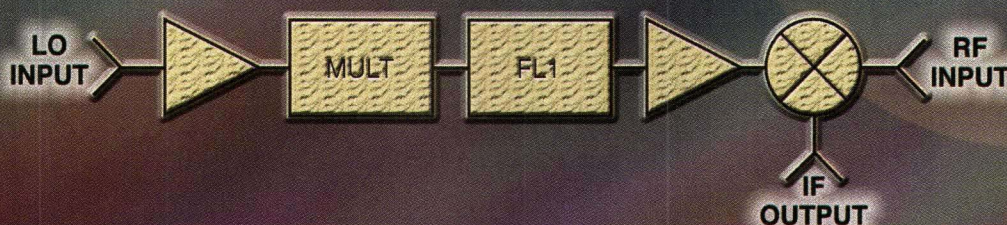


## MULTIPLIERS

Model Number	Frequency (GHz)		Input Power (dBm)	Output Power (dBm, Typ.)	Fundamental Leakage (dBc, Typ.)
	Input	Output			
SYS2X1428	14	28	+12	+12	-50
SYS2X1734	16-17.5	32-35	+12	+12	-50
SYS3X1442	14	42	+12	+12	-50
SYS4X1146	11	46	+12	+15	-60
SYS2X2040	10-20	20-40	+12	+15	-15
TD0040LA2	2-20	4-40	+10	-5	-20



## MIXER/MULTIPLIER ASSEMBLIES



Model Number	Frequency (GHz)			LO Power (dBm)	Conversion Loss (dB, Typ.)	Input IP <sup>3</sup> (dBm, Typ.)	Fundamental LO-RF Isolation (dB, Typ.)
	RF	LO	IF				
SYSMM2X2335	23.67-35.33	11.385-17.665	.04-.230	13-15	12	+15	50
SYSMM3X2640	26.5-40	8.8-13.3	DC-.5	10	10	+15	40

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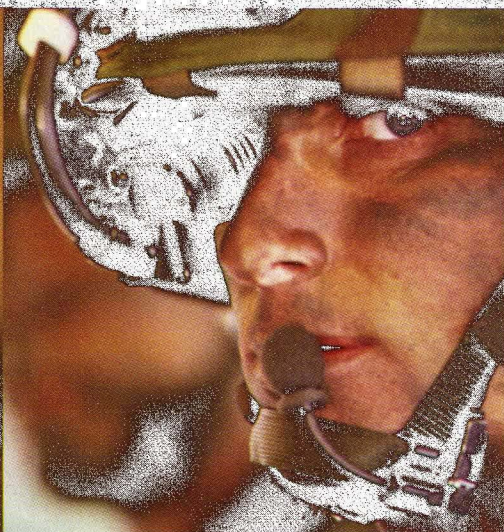
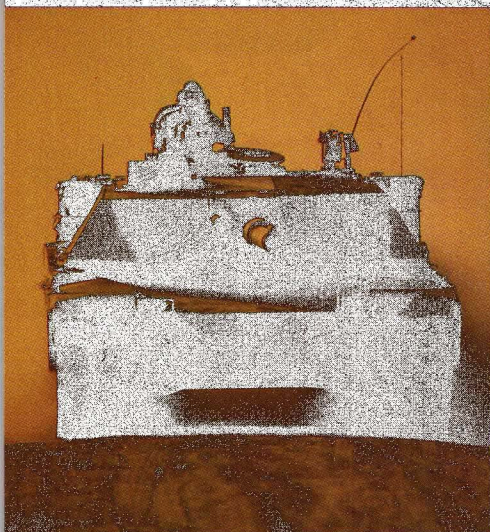


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## Temperatures Rising?

►► THE COVER FEATURE article in the April 2002 issue of *Microwaves & RF* (pp. 86-90) does a good job of conveying the benefits of Mini-Circuits' new MNA series of monolithic-microwave-integrated-circuit (MMIC) amplifiers except for some numerical errors that crept into the second-to-last paragraph in the story regarding the thermal performance of the amplifiers.

In all cases where a temperature was cited, an extra zero has included in the printed value. For example, in the story, the thermal resistance of the MNA series amplifiers, from junction to case, is given as 780°C/W. In fact, the thermal resistance of the amplifiers is only 78°C/W.

Further on in the paragraph, the story notes that for MNA amplifiers with +17-dBm output power, the junction-temperature rise above the case temperature is 350°C. In fact, this tem-

perature rise is only 35°C. In addition, the story mentions that at a case temperature of +850°C, the junction temperature is +1200°C. In fact, this should read "at a case temperature of +85°C, the junction temperature is +120°C."

The paragraph also addresses the temperature rise due to soldering, stating that, when soldered onto a printed-circuit board (PCB), the MNA amplifier case temperature typically rises 100°C above the ambient temperature, making the junction temperature +1300°C. In fact, this should read that the MNA amplifier case temperature typically rises 10°C above the ambient temperature, making the junction temperature +130°C. In reality, no solid-state circuitry, military or commercial, could withstand temperatures in the range of +850°C and +1200°C.

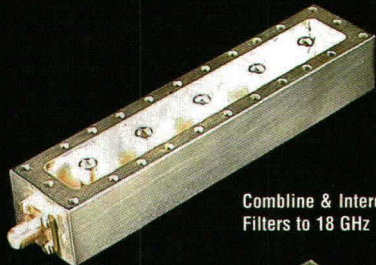
**Bruce Marks**  
Mini Circuits  
Brooklyn, NY

## Editor's Note:

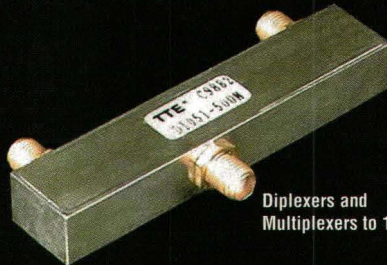
Our apologies to Mr. Marks and the engineering team at Mini-Circuits, who continue to develop a wide range of high-performance, practical products for RF/microwave applications. The MNA amplifiers, in fact, are characterized by outstanding thermal characteristics, with the capabilities of efficiently dissipating heat. They are thus rated for extremely long mean time to failure (MTTF) and high reliability even at elevated operating temperatures. Hopefully, most of our readers spotted the discrepancies in the temperatures and realized that such temperatures would not be found in real-world operating conditions. The errors crept in due to mistakes in typesetting the article (degree signs turned to zeros). Hopefully, they do not detract too much from the message about the fine value/performance of these MNA amplifiers.

# 1,239,580 Filters

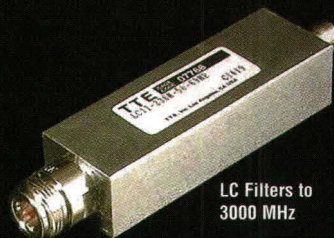
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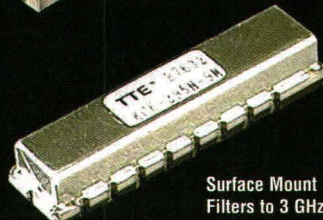
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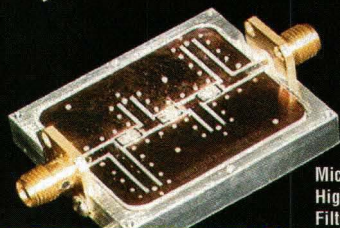
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Multiplexers to 18 GHz



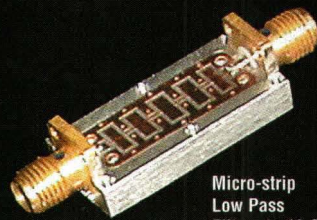
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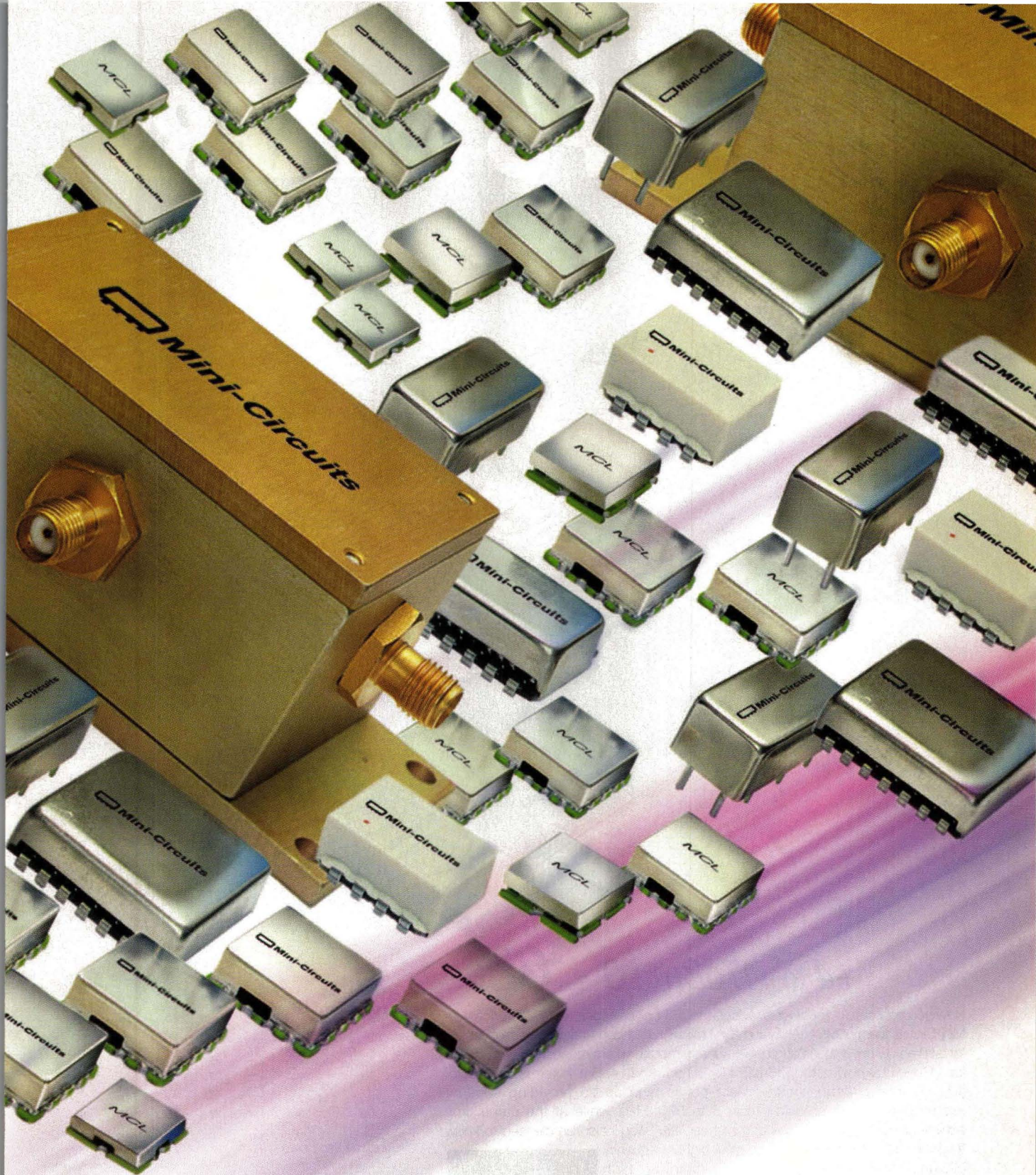
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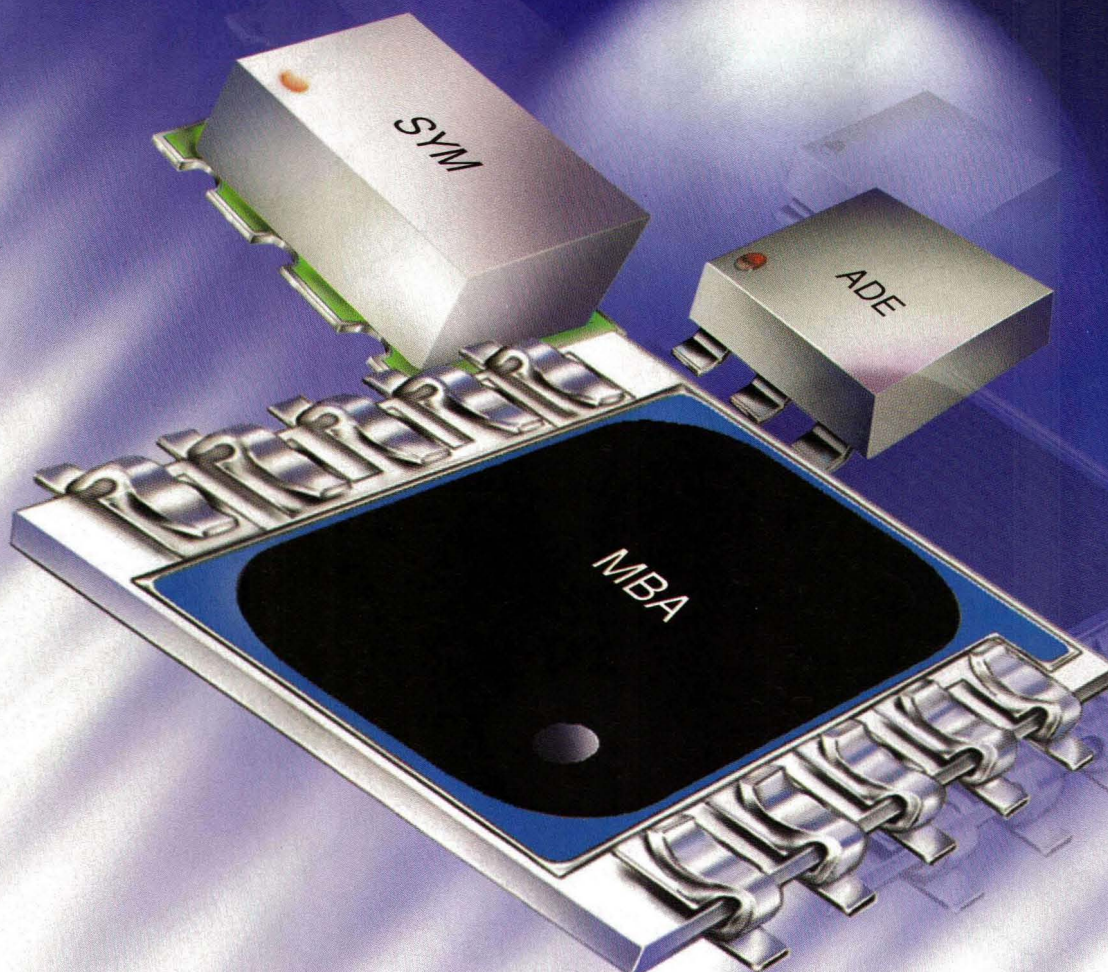
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•MBA-591L	4950-5900	+4	15	1.1	7.0	6.95
SYM-25DLHW	40-2500	+10	22	1.2	6.3	7.95
SYM-25DMHW	40-2500	+13	26	1.3	6.6	8.95
SYM-24DH	1400-2400	+17	29	1.2	7.0	9.95
SYM-25DHW	80-2500	+17	30	1.3	6.4	9.95
SYM-22H	1500-2200	+17	30	1.3	5.6	9.95
SYM-20DH	1700-2000	+17	32	1.5	6.7	9.95
SYM-18H	5-1800	+17	30	1.3	5.75	9.95
SYM-14H	100-1370	+17	30	1.3	6.5	9.95
SYM-10DH	800-1000	+17	31	1.4	7.6	9.95

\*E Factor =  $[IP3 (dBm) - LO Power (dBm)] / +10$ . See web site for E Factor application note.

ADE models protected by U.S. patent 6,133,525.

•MBA Blue Cell™ model protected by U.S. patents 5,534,830 5,640,332 5,640,699.



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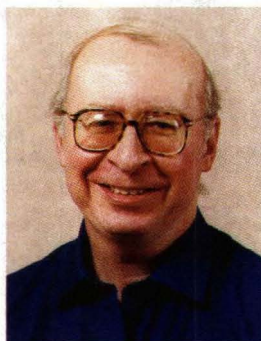
# The US Military Must Stay Strong

Military electronics has long been the backbone of the microwave industry. For many companies, it was the only source of business. But then that long-awaited commercial application—in wireless communications—came along during the 1990s. Many companies were lured by all the promises of fast growth and wealth from wireless service providers, infrastructure builders, and handset suppliers, and many said “farewell” to their former customers on the military side.

Business is cyclical in most markets, however, and the microwave industry is no exception. Almost as quickly as the wireless markets emerged and expanded, they seemed to fade and collapse. And many of those companies who had been quick to leave their traditional military customers for lucrative, higher-volume commercial wireless customers got to experience the uncomfortable taste of crow.

The two terms of office held by Mr. Clinton during the 1990s represented tremendous commercial prosperity, but at a price to our military. The US military has long carried an aura of invincibility that has served as a deterrent to hostile forces. As Mr. Clinton slashed more and more away from the defense budgets during his years as President, hostile forces and terrorists around the globe began to believe that perhaps the US military was not to be feared, that it was not the unstoppable force of years past.

Mr. Bush has taken bold steps to correct matters for the military. And the microwave industry is seeing some of the trickle-down effects of the additional funding, especially welcome during a time of softened wireless business. The Military Electronics Show (MES), scheduled for September 24-25, 2002 in the Baltimore Convention Center, is our small way of trying to help bring greatness back to the US military. It is an event aimed at design engineers working in military electronics, with the intention of providing them a venue for sharing technical ideas and spending some time with suppliers. So far, some prestigious engineers have expressed interest making technical presentations at the show, including Steve Best of Cushman, Dick Bernstein of BAI Aerosystems, Uri Yaniv of Elcom Technologies, and Radha Setty of Mini-Circuits. Presentations will be one-half hour in length and covering a wide range of topics, from components, receivers (Rx), and transmitters (Tx) to software and measurements. If you would like to make a presentation at the show, drop me a line at [jbrowne@penton.com](mailto:jbrowne@penton.com) with your presentation idea. Join us in helping to make the US military strong once more.



*Hostile forces and terrorists around the globe began to believe that the US military was not to be feared, that it was not the unstoppable force of years past.*

*Jack Browne*  
Publisher/Editor

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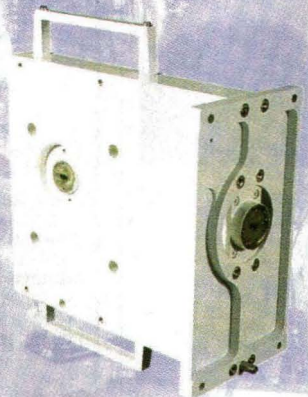
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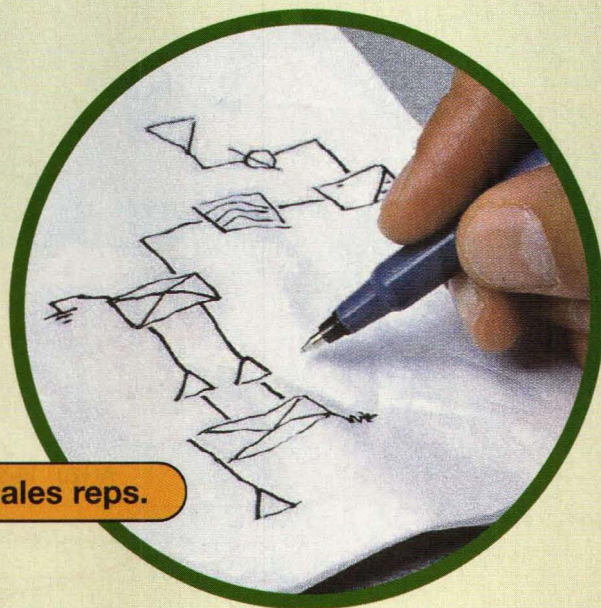
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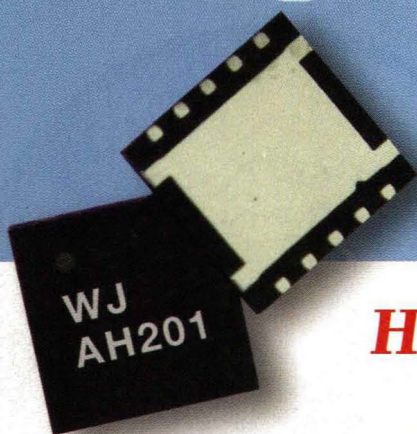
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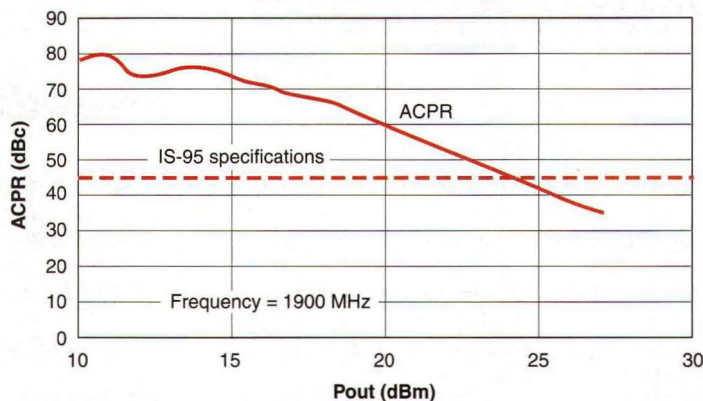
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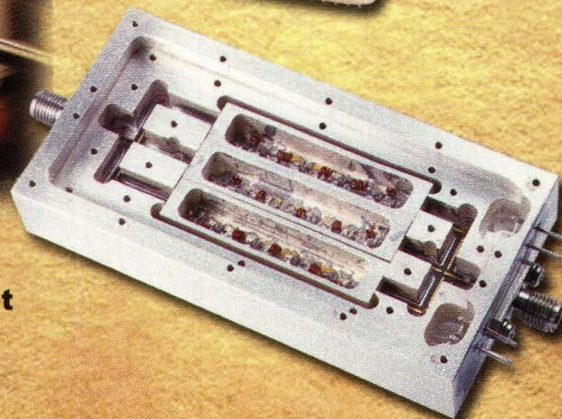
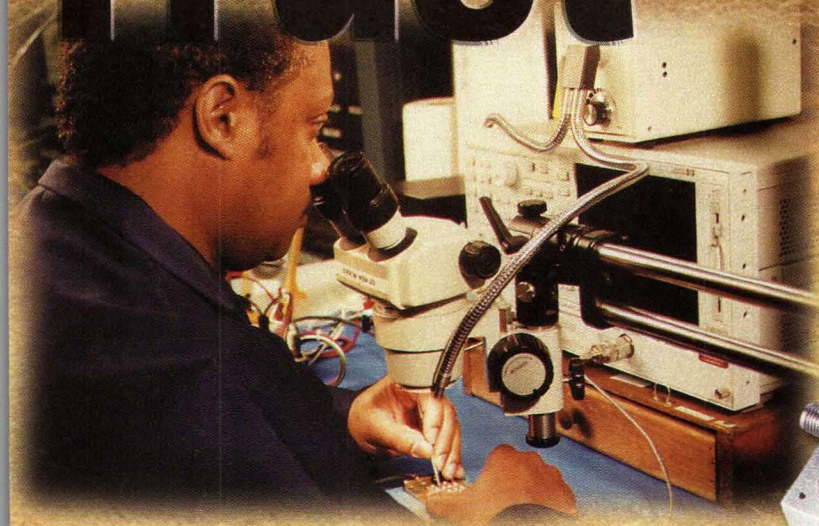
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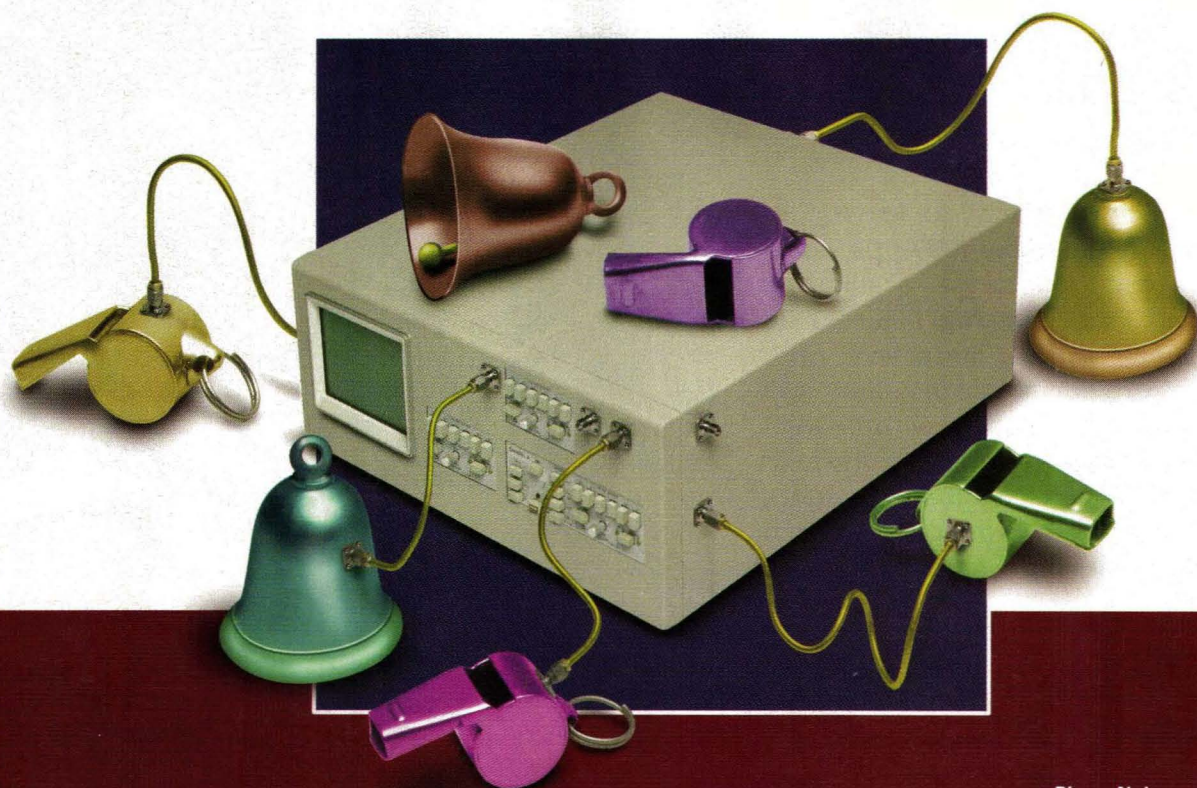
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Micro Lambda Wireless, Inc. a leader in the development of next-generation YIG devices introduces a new line of high performance frequency synthesizers covering the 600 MHz to 10 GHz frequency range. Designed specifically for wide band and low noise applications, these new frequency synthesizers rival the best lab-grade test instruments on the market.

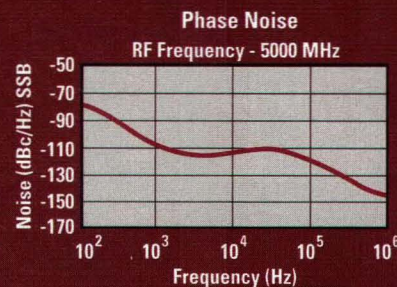
### MLSW-SERIES WIDE BAND FREQUENCY SYNTHESIZERS.

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requirements. External reference frequency of 10 MHz is utilized, but 5 to 50 MHz are offered as options. Excellent phase noise performance at 10 kHz offset of -110 dBc/Hz, -108 dBc/Hz and -106 dBc/Hz are provided for the 0.6 GHz to 3 GHz, 2 GHz to 8 GHz and 2 GHz to 10 GHz units respectively. The units operate from +15 Volt and +5 Volt supply lines and frequency control is via a 5-wire serial (SPI & busy) input protocol. Options include dual RF outputs and/or an L-band 2<sup>nd</sup> L.O. All units measure 5" x 7" x 1" and weigh 28 oz.

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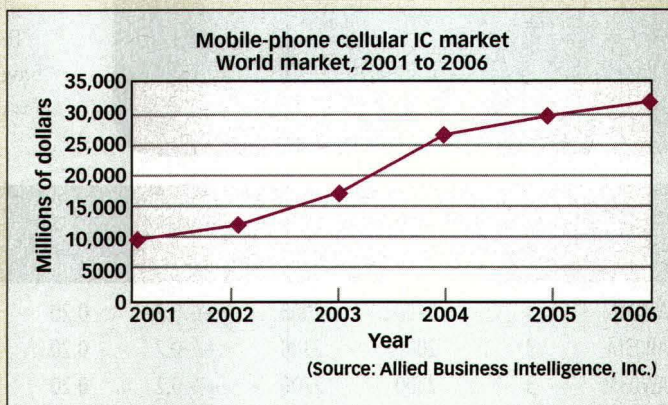
## Next-Generation Cellular-Handset Demand To Aid Component Sector

OYSTER BAY, NY—Despite short-term sluggishness in the cellular integrated-circuit (IC) market, long-term growth will be exceptional, according to an Allied Business Intelligence (ABI) report. Increased demand for enhanced cellular handsets that have higher IC content than current second-generation (2G) devices will fuel new growth in the market. According to the study “3G/Cellular Integrated Circuits,” the total available cellular-IC (CIC) market will grow from \$9.7 billion in 2001 to \$31.5 billion in 2006 (see figure).

Slow network upgrades have stalled the market for ICs used in cell phones. However, phone makers are including attractive features in next-generation phones to lure in buyers regardless of the status of network upgrades.

“In turn, tomorrow’s feature-laden phones will fund lucrative growth in the IC market,” states Andy Fuertes, ABI’s director of Wireless Research. “Phones will cease to be just phones and IC vendors will benefit from a virtual endless potential for upgrades and increases in features.”

The move toward complete solutions will impact gallium-arsenide (GaAs) and silicon (Si) players alike as multimedia functionality is emphasized over conventional communications. Consolidation and convergence will be pervasive in all stages of cellular-handset design, as next-generation technologies lure newcomers into the cellular space.



## ITV Digital Collapse Could Stall Growth of DTT In The UK

LONDON, ENGLAND—According to reports from Reuters, the British Broadcasting Corp., and *The Times* of London, the collapse of the ITV Digital network could have damaging repercussions for the future of digital terrestrial television (DTT) in the United Kingdom. The prime reason for the financial collapse of ITV Digital is the three-year contract that it signed to televise matches of the Nationwide Football League. The number of subscribers to the service was drastically below expectations, which resulted in ITV Digital lacking the funds to continue payment on the contract to televise the Football League’s matches. ITV Digital still owes the Football League 178.5 million pounds (approximately \$261.06 million) for

the remaining two years on the contract.

ITV Digital was the world’s first DTT service. ITV’s Digital’s signal could be received through a regular TV aerial. A set-top box was used to de-encrypt the signal. The main selling point of the service was that no satellite dish or cable was necessary in order to receive programming.

Carlton Communications and Granada Media Group, the UK’s two largest TV broadcasters, were the shareholders in ITV Digital. The service, then known as ONdigital, was launched in November 1998.

The UK government had hoped to convert every home in the nation to digital TV by 2010. The government planned to sell off the analog spectrum for a considerable price. The sale of 3G mobile-phone licenses raised 22.5 billion pounds (about \$32.9 billion) in March 2000.

# Introducing Stripline Couplers for a wireless world.

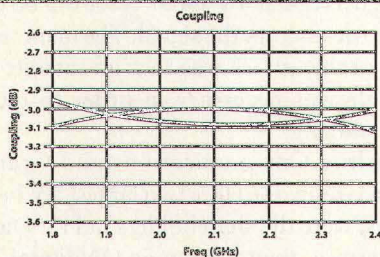
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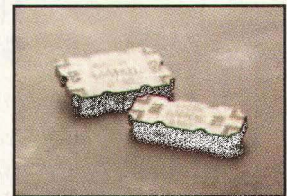
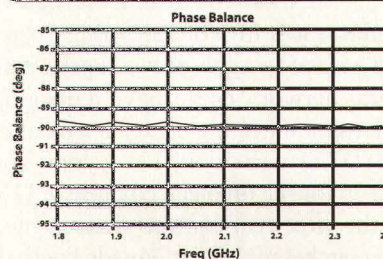
Part Number	Coupling Frequency	Start Frequency	Stop Frequency	Amplitude Balance (dB max.)	Insertion Loss (dB max.)	Phase Balance (Degrees max.)	Isolation (dB min.)	VSWR (max:1)	Power Handling (Watts)	Package
AM03M	3	1700	2000	+/- 0.2	0.20	2	23	1.17	60	0.56"x 0.20"x 0.072"
AP03M	3	2000	2300	+/- 0.2	0.20	2	23	1.17	60	0.56"x 0.20"x 0.072"
AW03M	3	2300	2700	+/- 0.2	0.20	3	22	1.18	60	0.56"x 0.20"x 0.072"
BC03M	3	3300	3700	+/- 0.2	0.20	4	22	1.19	60	0.56"x 0.20"x 0.072"
AH03L	3	815	960	+/- 0.3	0.23	3	22	1.18	150	0.56"x 0.35"x 0.075"
AN03L	3	1500	2200	+/- 0.4	0.25	3	20	1.20	100	0.56"x 0.35"x 0.075"
AR03L	3	1800	2200	+/- 0.2	0.25	3	20	1.20	100	0.56"x 0.35"x 0.075"
AV03L	3	1800	2700	+/- 0.5	0.30	5	18	1.25	60	0.56"x 0.35"x 0.075"
AS03L	3	1930	1990	+/- 0.15	0.23	2	21	1.17	100	0.56"x 0.35"x 0.075"
<b>AP03L</b>	<b>3</b>	<b>2000</b>	<b>2300</b>	<b>+/- 0.2</b>	<b>0.20</b>	<b>2</b>	<b>23</b>	<b>1.17</b>	<b>60</b>	<b>0.56"x 0.35"x 0.075"</b>
AY03L	3	3400	3500	+/- 0.3	0.30	5	21	1.25	60	0.56"x 0.35"x 0.075"

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## London Police Set Trap For Mobile-Phone Thieves

LONDON, ENGLAND—The theft of mobile phones on London streets continues to be a huge problem. (See “London’s Metropolitan Police Launch Mobile-Phone Theft-Prevention Campaign,” November 2001, p. 26.) London’s skyrocketing mobile-phone theft rate has become such a concern that England’s Lord Chief Justice, Lord Woolf, stated in February that mobile-phone thieves should receive prison sentences of five years or more. In the period from April to December 2001, there were 97 percent more offenses where the only item stolen was a mobile phone than during the same period in 2000. About half of the 45,000 street crimes that were committed in London during 2001 concerned the theft of a mobile phone.

In a further effort to crack down on the plague of phone thefts, the Metropolitan Police Service of London spearheaded a campaign earlier this year to get mobile-phone owners to

Sir John Stevens, Commissioner of London’s Metropolitan Police Service, helps a mobile-phone owner security mark his phone with an ultraviolet pen.



mark their phones with a property code using ultraviolet (UV) pens (see figure). The ink shows up under UV light. By using the ink to write the owner’s postcode and house number on an item of property, the property is permanently but discreetly marked. Personal digital assistants (PDAs) and laptop computers were also security marked during the initiative.

The campaign, which is known as UVID for “Ultra Violet Identification,” was run as part of the Metropolitan Police Service’s Safer Streets initiative. London radio station Capital Radio, the *Evening Standard* newspaper, and The Link mobile-phone shops also participated in the campaign.

Members of the Metropolitan Police Service handed out leaflets and UVID stickers which warn potential thieves that the property had been UVID marked and that the police would be able to easily identify it if it is stolen. The UVID teams

worked at shopping centers and in robbery hotspots, such as London Underground tube stations. The police also reminded the mobile-phone owners to record the International Mobile Equipment Identification (IMEI) number of their phone so that it can be supplied to the police if the phone is stolen.

Ken Livingstone, Mayor of London, commented, “London has seen a dramatic increase in street robbery, and in particular thefts of mobile phones, over the last year. I believe that the best way to tackle this problem is with high-visibility policing and already I have provided funds for the recruitment of an extra 2250 Metropolitan Police officers.

“In addition to increasing the number of police patrolling the streets, innovative Met Police campaigns such as the UVID are an invaluable tool in the fight against crime, approaching the problem from a different angle. I believe such preventative schemes coupled with high-visibility policing will help us win the fight against street robbery in London.”

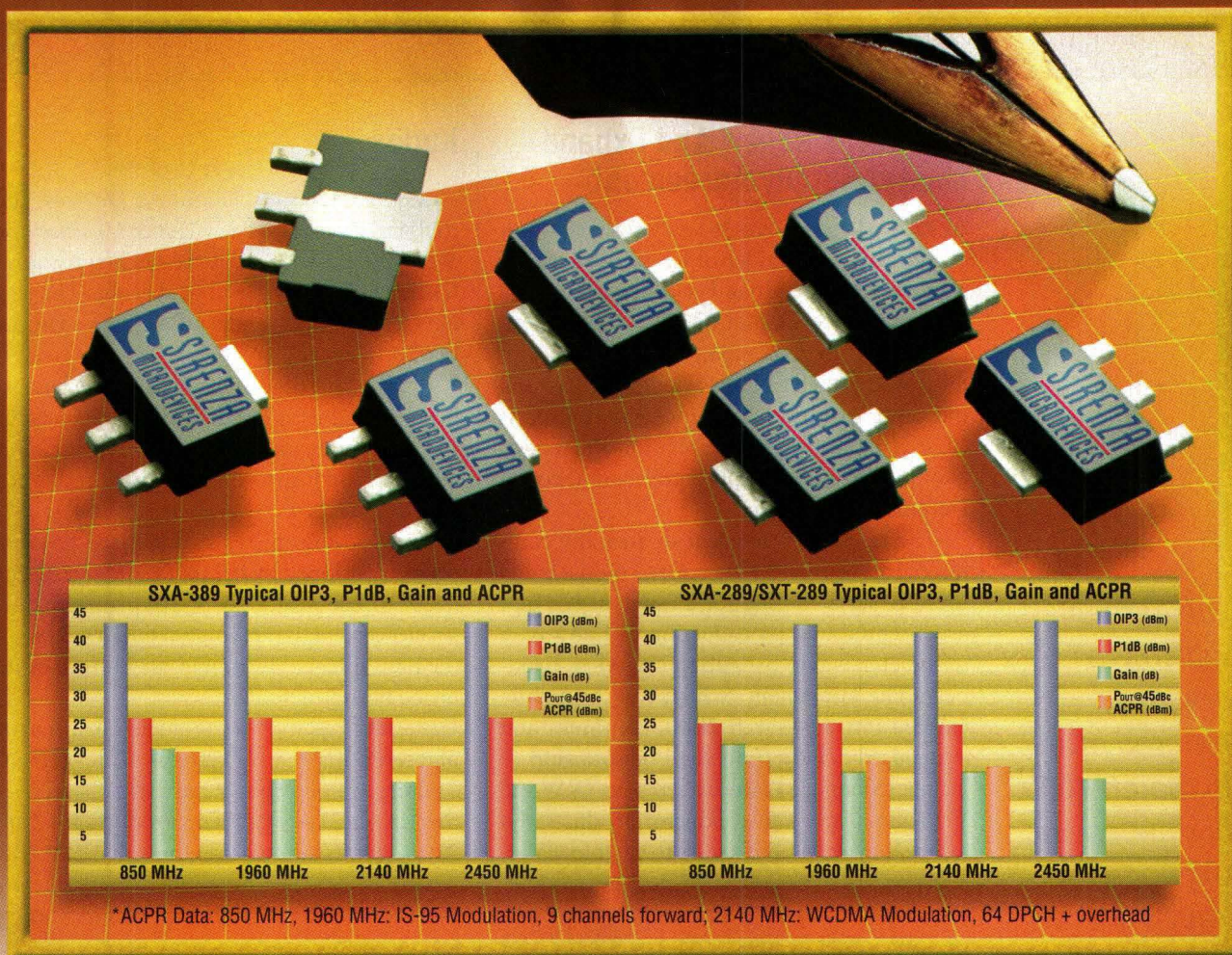
At the start of the UVID initiative, Metropolitan Police Service Commissioner Sir John Stevens said, “I hope as many mobile-phone owners as possible take advantage of the Safer Streets campaign.

“Have your mobile phone UVID marked and record your IMEI number,” continued Stevens. “It will really help us catch mobile-phone robbers, you will stand a much better chance of getting your property back, and it could deter a thief from stealing it in the first place.”

## Electronics Firms Enter Into BGA Licensing Agreement

HARRISBURG, PA—Tyco Electronics, a unit of Tyco International Ltd., has announced a licensing agreement with FCI Electronics covering ball-grid-array (BGA) technology and microprocessor sockets. Tyco has granted FCI the rights to Micro PGA socket designs, and FCI has granted Tyco specific rights to use FCI’s patented BGA technology for application to Micro PGA Microprocessor sockets.

Greg Sites, director of product management for Tyco Electronics’ Communications, Computer, and Consumer Electronics Division, commented, “By working together, we and FCI are in an excellent position to meet the expectations of our customers, especially with respect to the high growth demand for these sockets.”



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400–2500 MHz cellular, ISM, WLL, PCS and WCDMA bands, it's priced at just \$4 each in quantities of 10,000.



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## Two Firms Renew And Expand Master Supply Agreement

EL SEGUNDO, CA AND SUNNYVALE, CA—Endwave Corp., a provider of RF subsystems for carrier-class, broadband wireless access and backhaul networks, and TRW's telecommunication-products company, Velocium, a supplier of advanced gallium-arsenide (GaAs) and indium-phosphide (InP) integrated circuits (ICs), have announced the revision and renewal of their Master Supply Agreement through December 31, 2005.

The renewal agreement defines the commercial terms and tenure for GaAs products and foundry services used for a range of ICs that are essential to the production of Endwave's millimeter-wave, broadband wireless products. The agreement, which was originally entered into in March 2000, continues and expands the TRW/Endwave relationship to include: continued Endwave access to TRW and Velocium GaAs semiconductor products and technology; enhanced access to custom wafer-processing services; expanded access to GaAs process technologies; expanded access to products operating at lower frequency bands for wireless infrastructure applications; access to Velocium's InP products for advanced applications; and guaranteed pricing and purchase commitments.

"On behalf of TRW and Velocium, we are extremely pleased to continue and expand our technology partnership with Endwave, a market leader in RF subsystems for broadband wireless infrastructure," commented Dwight Streit, Velocium's president. "Endwave's design expertise and world-class manufacturing capability, coupled with our semiconductor-processing technologies, will give leading radio OEMs and other equipment manufacturers access to TRW technology and performance, packaged as they need it."

"TRW is known worldwide for their high-performance, highly reliable GaAs and InP semiconductor technologies for millimeter-wave applications, and we are pleased to be able to expand our long-standing relationship with TRW and Velocium," stated Ed Keible, CEO and president of Endwave Corp. "Our relationship with TRW provides us with a competitive advantage in the market, and allows Endwave to leverage TRW's advanced semiconductor-processing technologies in developing next-generation product solutions for our customers."

*"The agreement, which was originally entered into in March 2000, continues and expands the TRW/Endwave relationship."*

## Kudos

KANSAS CITY, KS—Interconnect Devices, Inc. (IDI) has been honored in *Test & Measurement World Magazine's* annual "Best in Test Awards." IDI was honored for its Focal Probe. The winners were featured in the publication's December 2001 issue.

At the same time, IDI's Focal Probe has also been named as a Finalist in the "Excellence Awards" sponsored by *EP&P Magazine* in the "Test and Inspection Equipment and Accessories" category.

The Focal Probe is a spring-loaded contact probe, developed by IDI that enables test engineers to use larger, stronger probes to test smaller centers. To accomplish this, IDI designed the first "pluggable" tail in the bottom of the probe barrel.

VISTA, CA—Palomar Technologies, Inc., a manufacturer of assembly systems for broadband communications, announced that it has received the *Microwaves & RF* Top Products for 2001 Award for its automated HotRail™ RFA (RF) Assembly Cell. The award for Top Products of 2001 is based on a combination of technological innovation and practical merit.

In addition, Palomar announced that its Laser Diode Attach Cell (LDA) was selected as a *Fiberoptic Product News* 2001 Technology Award Winner. Palomar's LDA system automates the high-precision assembly process of complex laser-diode packages, enabling optoelectronic manufacturers to meet volume requirements by increasing yield and throughput while reducing costs. The award was presented at the Optical Fiber Communications Conference in Anaheim, CA on March 19.

Winners were selected from the more than 2000 new products that appeared in *Fiberoptic Product News* in 2001. After a vote by the *FPN* readers, the top 50 products were reviewed by *FPN* editors, who chose 27 nominees in six product categories.

CENTENNIAL, CO—OnLine Power Supply, Inc. (OPS) announced that it has submitted its 1000-W, +48-VDC power supply, the OPS-1000-48, for UL and TUV safety certification.

The OPS-1000-48, the first in a planned series of isolated, single-output products from OPS, will be tested and evaluated by INTERtest Systems, Inc. of Colorado Springs, CO. INTERtest will manage the process for UL, TUV Bauart, and CB certification, as well as electromagnetic-compatibility (EMC) testing. **MRF**

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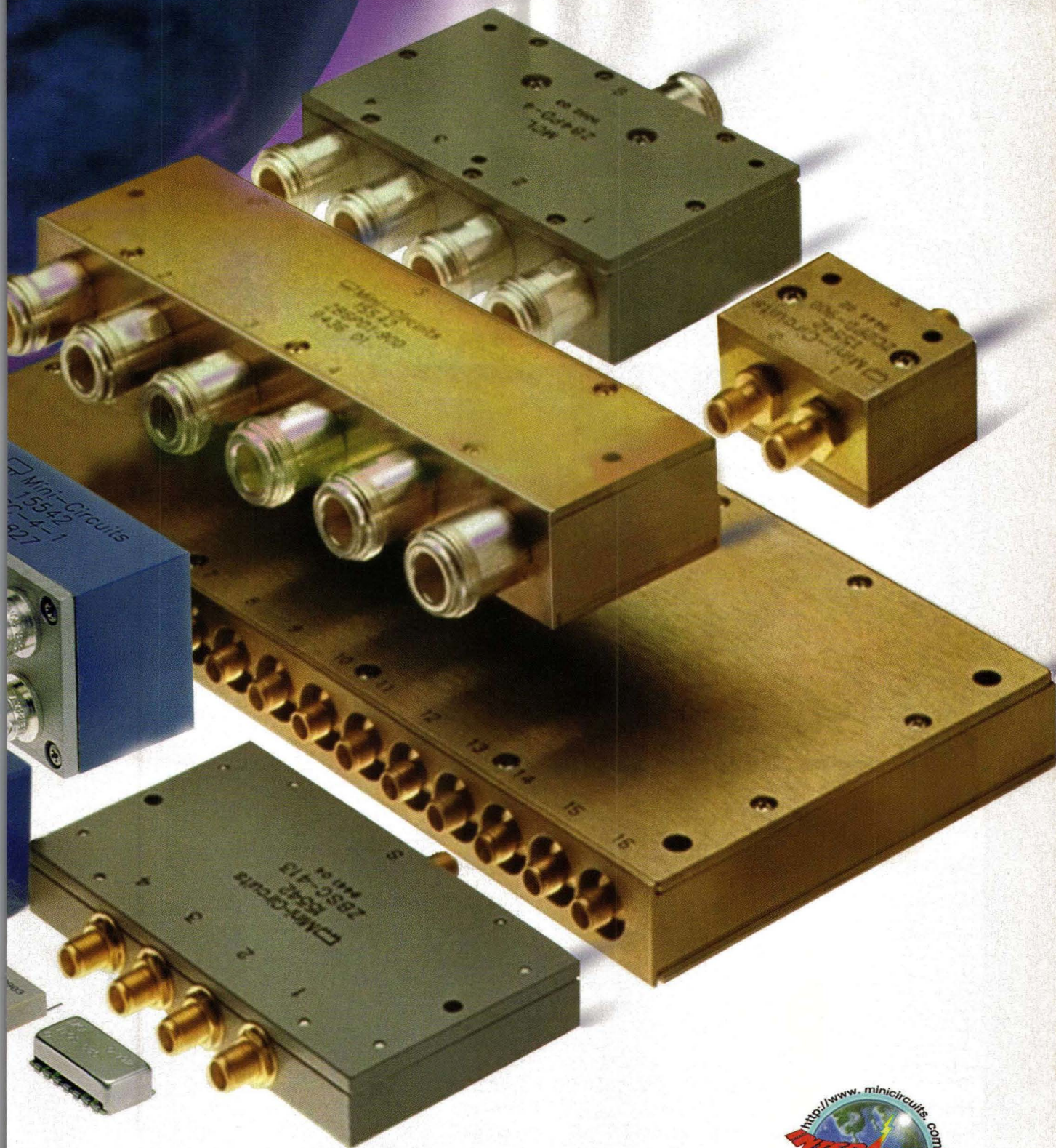
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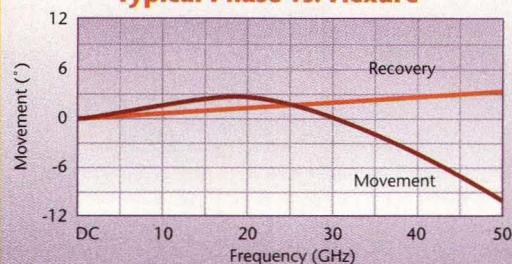
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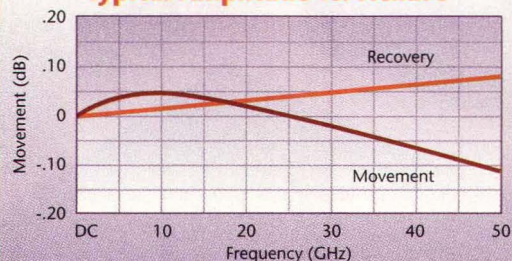
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<b>DC - 8 GHz</b>	VN8	TM8	SL8	SF8
<b>DC - 18 GHz</b>	VN18	TM18	SL18	SF18
<b>DC - 26 GHz</b>	VN26	TM26	SL26	SF26
<b>DC - 40 GHz</b>	VN40	TM40	SL40	-
<b>DC - 50 GHz</b>	VN50	TM50	SL50	-
<b>Max. Frequency</b>		50 GHz		26.5 GHz
<b>Inner Conductor</b>		Solid		Stranded
<b>Dielectric</b>		Solid PTFE		PTFE Tape
<b>Outer Conductor</b>	<b>Super-Flexible Copper GrooveTube<sup>®</sup> by MegaPhase<sup>®</sup></b>			
<b>Finished Outer Diameter</b>	0.625 in. 15.88 mm	0.285 in. 7.24 mm	0.500 in. 12.70 mm	0.285 in. 7.24 mm
<b>Ruggedization</b>	Metal Braid over Metal Armor	Metal Braid	Metal Braid over Metal Armor	Metal Braid
<b>Outer Jacket</b>	PET Braid	Polyolefin	Neoprene	Polyolefin
<b>Bend Radius</b>	1.5 in. 38.1 mm	0.5 in. 12.7 mm	1.5 in. 38.1 mm	0.5 in. 12.7 mm
<b>Flexibility Rating – Highest = 5.0</b>	4.0	4.5	4.0	5.0

**Repeatable & Consistent Measurements:**

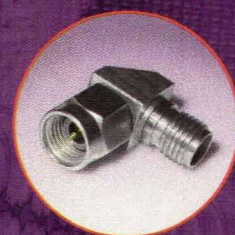
GrooveTube<sup>®</sup> is a super-flexible copper outer conductor that maintains its geometry – flexure after flexure. GrooveTube<sup>®</sup> doesn't cage, kink and fatigue like traditional braid/foil outer conductors. As a result calibrations won't degrade over time.

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# Attendance Grows At RF & Hyper Europe

The 28th RF & Hyper conference and exhibition features more than 200 exhibitors from all parts of the globe, showcasing new hardware and software for communications.

**S**truggling high-frequency markets have not taken their toll on one of the industry's increasingly popular trade shows, RF & Hyper Europe. Having just completed its 28th year, the RF & Hyper Europe, held this past March 26-28, 2002 at the Paris Expo (Port of Versailles), featured more than 200 exhibiting companies and more than 4000 attendees in a year during which many manufacturers are fighting

to remain flat in sales with 2001's paltry showings.

Although many exhibitors come to the RF & Hyper Europe show to strengthen their presence in French markets, the event has grown considerably beyond basic coverage of French high-frequency electronics and now includes exhibitors (and attendees) from throughout Europe and the US. For example, Marconi Applied Technologies (Chelmsford,

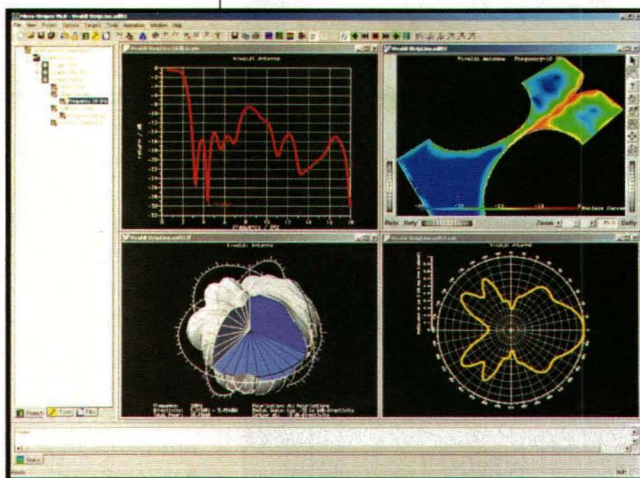
England; [www.marconitech.com](http://www.marconitech.com)) featured a wide range of high-power RF/microwave vacuum tubes, including

klystrons for television transmitters (Txs), magnetrons for radar Txs, and traveling-wave tubes (TWTs) for communications applications. The firm also showed complete TWT amplifiers, with TWT tubes and power supplies integrated into a common assembly, as well as lines of semiconductor diodes, such as Schottky, positive-intrinsic-negative (PIN), and Gunn devices, for applications through 110 GHz.

Temex (Phoenix, AZ; [www.temex.net](http://www.temex.net)) unveiled several new products at RF & Hyper Europe, including a line of beryllium-oxide ( $\text{BeO}_3$ )-free power terminations in a surface-mount configuration. The terminations, available in power ratings to more than 40 W and feature a low VSWR of 1.05:1. The company also introduced a line of phase-locked-loop (PLL) frequency synthesizers for wireless applications. Available from 750 to 2500 MHz, the PLLs offer bandwidths as wide as 20 percent of the center frequency, single-sideband phase noise as low as  $-148$  dBc/Hz at 1 GHz, and simple three-wire pro-

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Version 6.0 of the Micro-stripes EM simulation and analysis software program from Flomerics simplifies the design of antennas and other microwave components with a variety of new automatic features.



grammability. The PLLs are provided in a surface-mount package measuring  $19 \times 14$  mm. The company's E6000 series of ceramic materials is ideal for microwave applications from 0.9 to 6.0 GHz.

Fordahl SA (Bienne, Switzerland; [www.fordahl.com](http://www.fordahl.com)) introduced the DFA

S-LECPI series of high-stability, temperature-compensated crystal oscillators (TCXOs) with frequency coverage of 150 to 180 MHz. Supplied in a package measuring only  $9 \times 14 \times 6$  mm, the TCXOs feature  $\pm 10$ -PPM stability over 10 years of use. Standard frequencies

include 155.520, 161.1328, 166.6286, and 167.33164 MHz.

Microlease plc (Harrow, Middlesex, England; [www.microlease.com](http://www.microlease.com)) featured a new CD-ROM with extensive listings of their test equipment for rent or lease, including signal analyzer and signal generators from such sources as Agilent Technologies (Santa Clara, CA; [www.agilent.com](http://www.agilent.com)) and Rohde & Schwarz (Munich, Germany; [www.rohde-schwarz.com](http://www.rohde-schwarz.com)).

IMS Connector Systems ([www.IMSCS.com](http://www.IMSCS.com)) announced plans to establish a French subsidiary, with IMS Connector Systems France to be founded in Nantes and starting operation in the second half of 2002. France will be home to the German-based manufacturer's eighth international subsidiary, with other locations including the US, China, Australia, Italy, and Hungary. The company supplies a wide range of high-frequency connectors, including surface-mount-assembly (SMA), SMB, BNC, TNC, and Type-N connectors.

Metrix (Paris, France; [www.metrix.fr](http://www.metrix.fr)) displayed its many lines of analog and digital multimeters, current meters, resistance meters, Gaussmeters, RF/microwave scalar-network analyzers, milliwatt meters, and oscilloscopes. For example, the Oritel MH 600 milliwattmeter measures power levels from  $-70$  to  $+44$  dBm at frequencies from 100 kHz to 50 GHz. The Oritel RF 600 scalar-network analyzer measures return loss, gain, and insertion loss at frequencies from 1 MHz to 2.7 GHz.

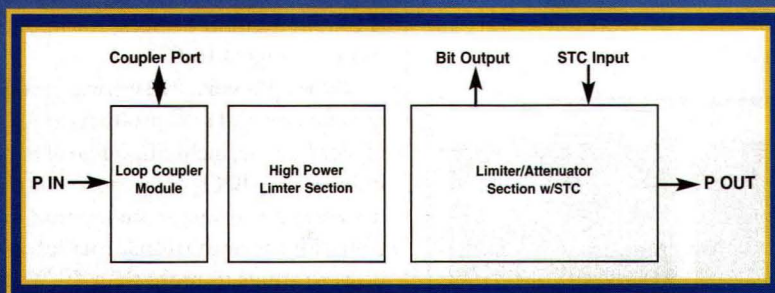
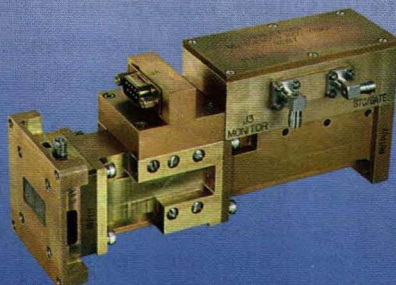
Flomerics (Hampton Court, Surrey, England; [www.flomerics.co.uk](http://www.flomerics.co.uk)) demonstrated Version 6.0 of the Micro-stripes EM analysis software (see figure) with new and improved features and automatic functions. The new version includes results and visualization tools built into the command window so that simulation results can be accessed without leaving that window. An upgraded "history" bar allows operators to quickly modify and optimize their designs. An "autolumping" feature combines small analysis cells in those model areas where smaller cells are not required to capture a structure's electromagnetic (EM) behavior. An auto-equivalent surface

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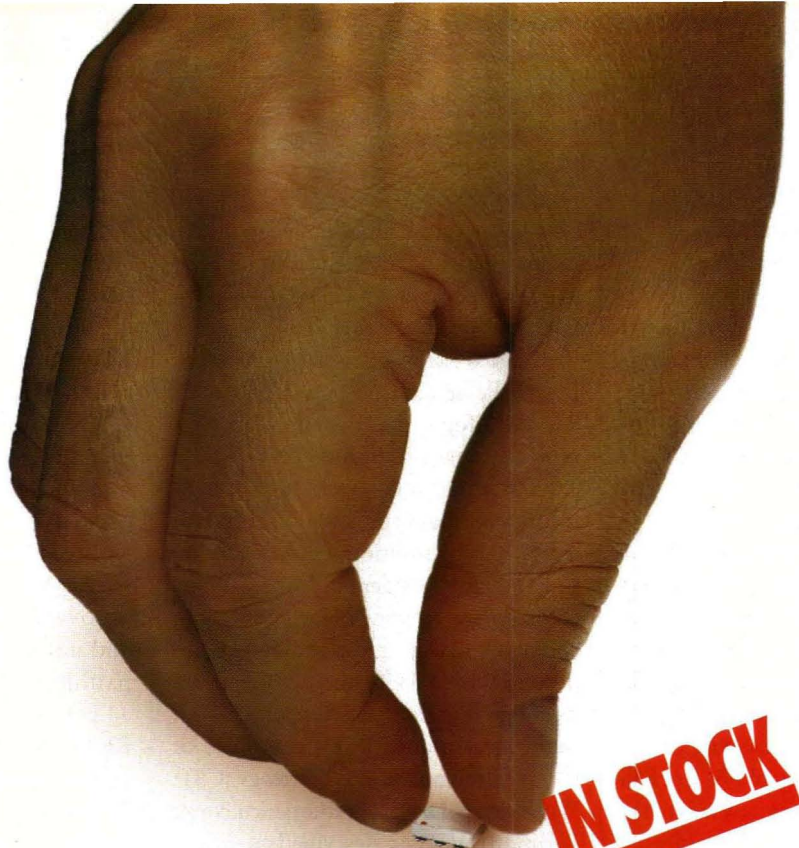


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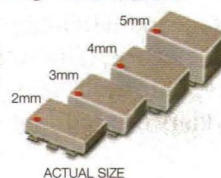
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ADE-3L	+3	0.2-400	5.3	47	10	4	4.25
ADEX-10L	+4	10-1000	7.2	60	16	3	2.95
ADE-1	+7	0.5-500	5.0	55	15	4	1.99▲
ADE-1ASK	+7	2-600	5.3	50	16	3	3.95
ADE-2ASK	+7	1-1000	5.4	45	12	3	4.25
ADE-6	+7	0.05-250	4.6	40	10	5	4.95
ADEX-10	+7	10-1000	6.8	60	16	3	2.95
ADE-12	+7	50-1000	7.0	35	17	2	2.95
ADE-4	+7	200-1000	6.8	53	15	3	4.25
ADE-14	+7	800-1000	7.4	32	17	2	3.25
ADE-901	+7	800-1000	5.9	32	13	3	2.95
ADE-5	+7	5-1500	6.6	40	15	3	3.45
ADE-5X	+7	5-1500	6.2	33	8	3	2.95
ADE-13	+7	50-1600	8.1	40	11	2	3.10
ADE-11X	+7	10-2000	7.1	36	9	3	1.99▲
ADE-20	+7	1500-2000	5.4	31	14	3	4.95
ADE-18	+7	1700-2500	4.9	27	10	3	3.45
ADE-3GL	+7	2100-2600	6.0	34	17	2	4.95
ADE-3G	+7	2300-2700	5.6	36	13	3	3.45
ADE-28	+7	1500-2800	5.1	30	8	3	5.95
ADE-30	+7	200-3000	4.5	35	14	3	6.95
ADE-32	+7	2500-3200	5.4	29	15	3	6.95
ADE-35	+7	1600-3500	6.3	25	11	3	4.95
ADE-18W	+7	1750-3500	5.4	33	11	3	3.95
ADE-30W	+7	300-4000	6.8	35	12	3	8.95
ADE-1LH	+10	0.5-500	5.0	55	15	4	2.99
ADE-1LHW	+10	2-750	5.3	52	15	3	4.95
ADE-1MH	+13	2-500	5.2	50	17	3	5.95
ADE-1MHW	+13	0.5-600	5.2	53	17	4	6.45
ADE-10MH	+13	800-1000	7.0	34	26	4	6.95
ADE-12MH	+13	10-1200	6.3	45	22	3	6.45
ADE-25MH	+13	5-2500	6.9	34	18	3	6.95
ADE-35MH	+13	5-3500	6.9	33	18	3	9.95
ADE-42MH	+13	5-4200	7.5	29	17	3	14.95
ADE-1H	+17	0.5-500	5.3	52	23	4	4.95
ADE-1HW	+17	5-750	6.0	48	26	3	6.45
ADEX-10H	+17	10-1000	7.0	55	22	3	3.45
ADE-10H	+17	400-1000	7.0	39	30	3	7.95
ADE-12H	+17	500-1200	6.7	34	28	3	8.95
ADE-17H	+17	100-1700	7.2	36	25	3	8.95
ADE-20H	+17	1500-2000	5.2	29	24	3	8.95

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setting allows operators to compute near- and far-field quantities without increasing the initial grid size.

Keithley Instruments (Cleveland, OH; [www.keithley.com](http://www.keithley.com)) announced two new switch modules for its models 2700 and 2750 multimeters. The models 7711 and 7712 switch modules offer 50- $\Omega$  input and output SMA connectors with frequency coverage to 2.0 and 3.5 GHz, respectively.

The RF & Hyper Europe event draws well for its strong exhibition area, but also offers several technical conferences. A total of 22 applications presentations staged by exhibitors showcased specific applications or technologies during 30-minute-long seminars. Alexander Gerfer of Wurth Elektronik GmbH & Co. KG (Niedernhall, Germany; [www.wurth-elektronik.de](http://www.wurth-elektronik.de)), for example, described a new filter balun component based on low-temperature-cofired-ceramic (LTCC) technology, while Gerard Bouisse of BFI

Optilas-Motorola (Sollentuna, Sweden; [www.bfi.avnet.com](http://www.bfi.avnet.com)) detailed a multi-mode, multiband 40-W laterally diffused metal-oxide-semiconductor (LDMOS) RF integrated circuit (RF IC).

Christos Tsironis of Focus Microwaves, Inc. (Ville St.-Laurent, Quebec, Canada; [www.focus-microwaves.com](http://www.focus-microwaves.com)) presented a new programmable 65-GHz coaxial impedance tuner using V connectors for load-pull and noise characterization. In addition, Harvey Kaylie, founder and President of Mini-Circuits (Brooklyn, NY; [www.minicircuits.com](http://www.minicircuits.com)), spoke on mixing traditional wire technology with LTCC and semiconductors to produce compact components with high performance levels. Founder of Computer Simulation Technology (CST; Wellesley, MD; [www.cst-america.com](http://www.cst-america.com)), Bernhard Wagner, described advanced techniques for the three-dimensional (3D) simulation of EM fields using Version 4.0 of the company's Microwave

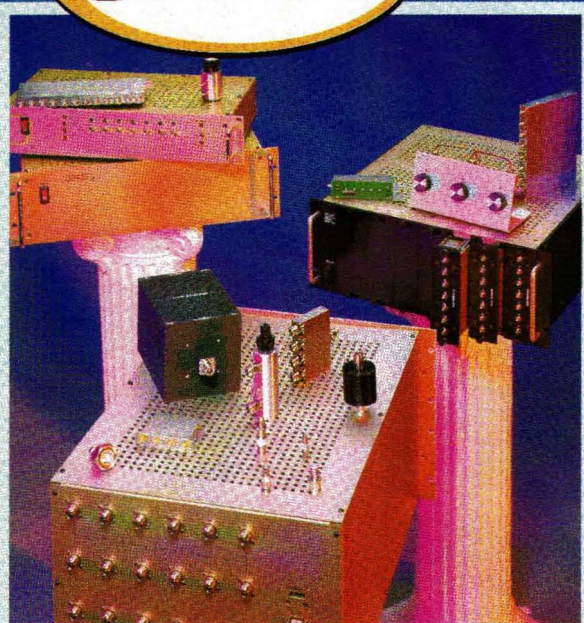
Studio EM simulation software. And Vincent Poisson of Agilent Technologies addressed the use of his company's computer-aided-engineering (CAE) software tools for the design of microwave and LTCC filters.

In addition to the applications presentations, RF & Hyper Europe also included the Compatibility Electromagnetic (CEM) Conference organized by the Association Francaise de Compatibilite Electromagnetique (AFCEM). The conference provided an overview of the latest directives and industry standards for EM compatibility (EMC).

For more information on next year's RF & Hyper Europe 2003 conference and exhibition, please contact Sylvie Cohen or Colette Rey, at BIRP, 17 avenue Ledru-Rollin, 75012 Paris, France; (33) (0) 1-53-171140, FAX: (33) (0) 1-53-171145, e-mail: [birp@birp.fr](mailto:birp@birp.fr), Internet: [www.birp.com](http://www.birp.com).



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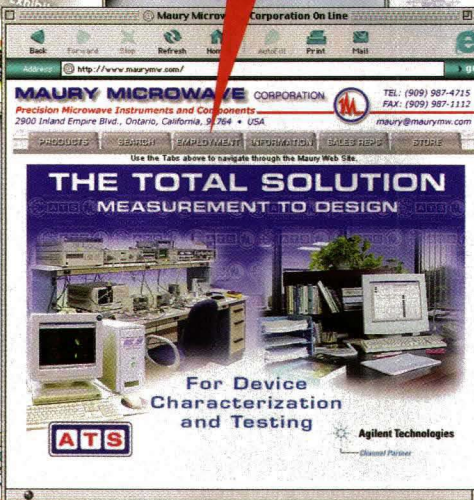
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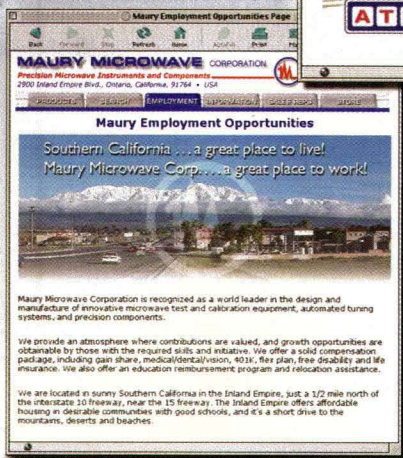
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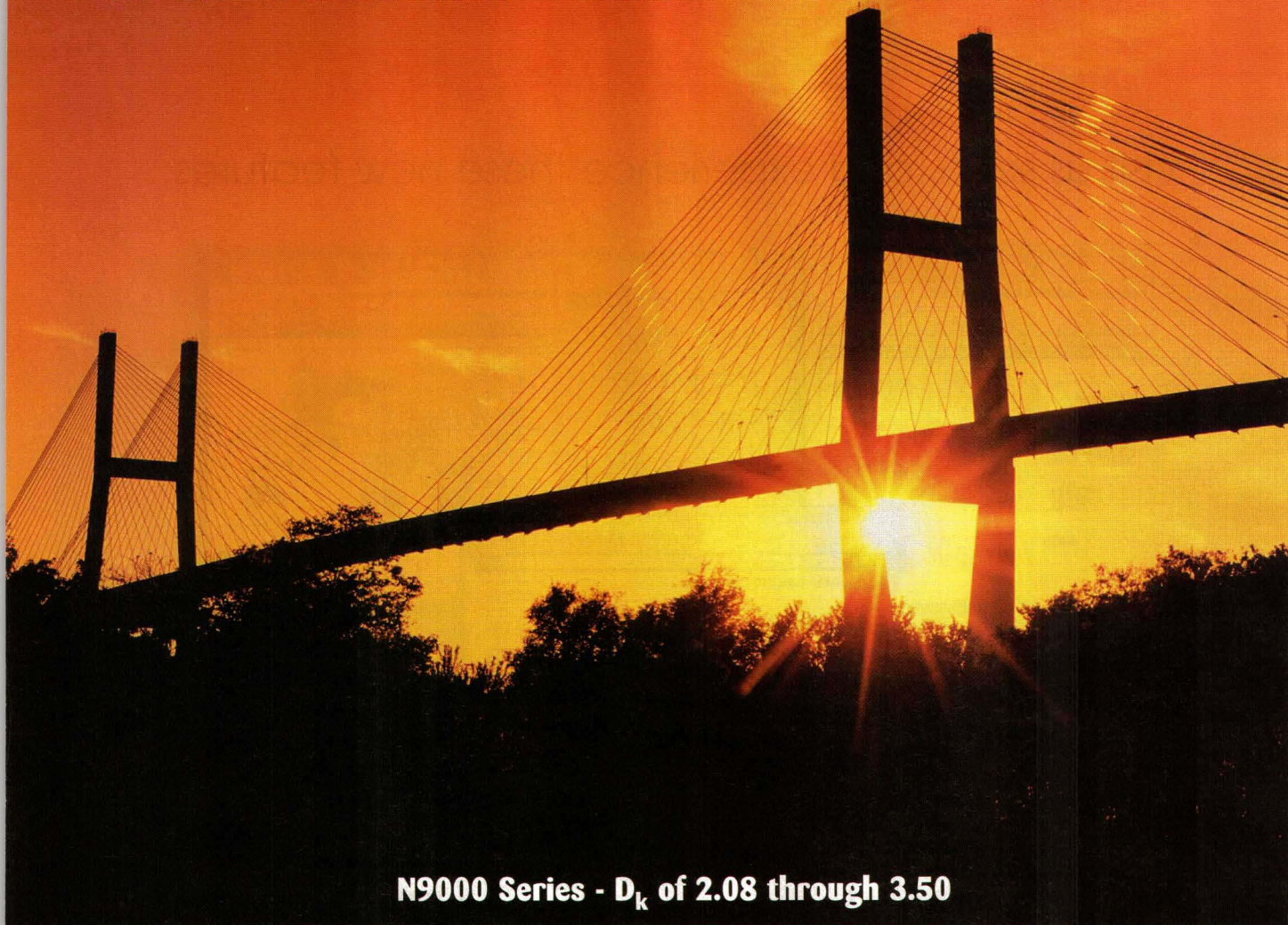
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# Conference Tackles 3G Test Challenges

The most recent meeting of the ARMMS RF & Microwave Society examined modelling and measurement issues facing designers of next-generation cellular telephones and equipment.

**T**hird-generation (3G) cellular systems promise improved performance and functionality, although the markets for these systems have not yet emerged with the vitality that was envisioned by many high-frequency prognosticators. Still, as part of the planning for simulating and testing these new systems, the 35th bi-annual meeting of the ARMMS RF & Microwave Society evaluated the potential problems

make more efficient use of bandwidth. His report reviews various new and emerging digital cellular standards, includ-

in modelling and testing emerging 3G designs. Held this past April 22 and 23, 2002 at the Hotel Elizabeth (Corby, Northamptonshire, England), the meeting included presentations from industry leaders from Filtronic Comtek, Racal Instruments, Agilent Technologies, Anritsu Co., Tality UK, Link Microtek, NERA, Philips Components/Antennas, and the National Physics Laboratory (NPL).

ARMMS RF & Microwave Society holds two meetings each year, each with two days of technical presentations devoted to a single theme. The theme of this most recent meeting, sponsored by Filtronic Comtek (UK) Ltd. (Saltaire, West Yorkshire, England), was "3G Design and Measurement Challenges." Appropriately enough, Andrew Kennerley of Filtronic Comtek opened the first day of technical presentations with his talk on "RF circuit design and test for intermediate-generation (2.5G) and 3G mobile communications." Kennerley noted that the main drivers for 2.5G and 3G mobile communications standards are to increase data rates, improve voice quality, and

ing Global System for Mobile Communications (GSM) phase 2+, Enhanced Data rates for Global Evolution (EDGE), and code-division-multiple-access (CDMA) systems, such as wideband CDMA (WCDMA) [backed by Europe, Japan, and Korea], cdma2000 (backed by the US), and single-carrier CDMA (SC-CDMA) [backed by China].

One of the challenges in testing 3G systems in general is that their data rates can vary on a frame-by-frame basis for the same user and, for CDMA systems in particular, that their power can vary as a function of modulation. These systems use orthogonal variable spreading factors (OVSFs) to allow variable rates among users. The use of OVSF codes makes other users on the same frequency appear as noise, even though these coded signals do not exactly possess noise-like characteristics. In addition, power control is required in some systems to keep users on the same channel from interfering with each other. As a result, designers of 3G systems are faced with challenging power measurements that are charac-

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Publisher/Editor

terized by wide dynamic ranges. Other key measurements mentioned by Kennerley include in-band testing of frequency, phase, and transmitted power; out-of-band dynamic and static spectrum measurements; and signal-related tests, such as frame-error-rate (FER) measurements.

Russell Cook of UbiNetics (Cambridge, England) gave a presentation entitled "Testing Challenges of 3G Infrastructure and Terminals." He noted that although network components (such as amplifiers and mixers) are currently tested at nominal conditions and at extremes of temperature, humidity, supply voltages, these measurements should also be conducted under dynamic conditions, including soft handover and at high data rates. Steve Gledhill of Racal Instruments, in his report, "3G Basestation and Mobile Test Challenges," also addressed Third Generation Protocol Project (3GPP) protocol testing and measurements for base-station installation commissioning.

Dave Schwartz and Tim Masson of Agilent Technologies (Palo Alto, CA) reviewed problems associated with WCDMA receiver (Rx) testing, in particular the challenges in performing the Reference Sensitivity Measurement, the key Rx sensitivity test described in ref. 4, section 6 of the WCDMA specifications. [Note that relevant copies of the WCDMA specifications pertaining to the frequency-domain-duplex (FDD) mode of operation can be downloaded from the 3GPP website at [www.3gpp.org](http://www.3gpp.org).] The reference-measurement channels are not unique features of the air interface, but simply represent decisions about which of the already-allowable configuration choices will be used for test purposes.

Steve Cripps of Hywave Associates, and a former presenter at the Wireless Symposium & Exhibition, offered a presentation on "Dynamic Measurements of PA Nonlinearities." Cripps notes that a typical "real-world" two-carrier intermod-

ulation (IM) spectrum contains a highly unbalanced group of third-order IM products, even though theory states that this should not happen. Even a single decibel of asymmetry has devastating consequences on attempts to linearize an amplifier's response using predistortion. This asymmetry is a function of bias, input and output impedance matching, and carrier separation. Even a few degrees of amplitude-modulation/phase-modulation (AM/PM) distortion can have a large impact on the amplitude of a correction signal. Cripps states that power amplifiers (PAs) are nonlinear devices with important hysteresis and "memory" effects which must be incorporated into device models before accurate simulations of nonlinear PA performance can be performed.

Shaun Cummins of Tality Corp.'s (San Jose, CA) Radio Systems Engineering department spoke on "Automated RF Design Verification Testing,"

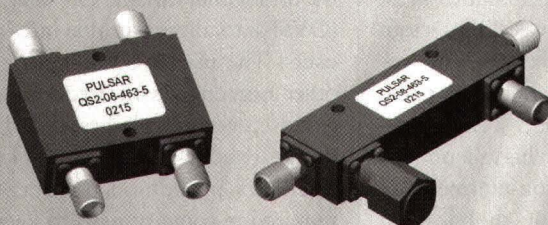
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1.0-2.0	0.1	28	1.2	3.0	1.15:1	QS2-02-*
2.0-4.0	0.1	22	1.2	4.0	1.20:1	QS2-03-*
2.6-5.2	0.1	20	1.2	4.0	1.25:1	QS2-04-*
4.0-8.0	0.2	18	1.4	4.0	1.25:1	QS2-05-*
2.0-8.0	0.3	17	1.6	6.0	1.30:1	QS4-01-*
6.0-12.4	0.2	17	1.4	6.0	1.40:1	QS2-06-*
4.0-12.4	0.3	17	0.8	7	1.35:1	QS2-07-*
7.5-16.0	0.4	15	0.6	8	1.40:1	QS2-08-*
12.0-18.0	0.4	15	0.7	8	1.40:1	QS2-09-*

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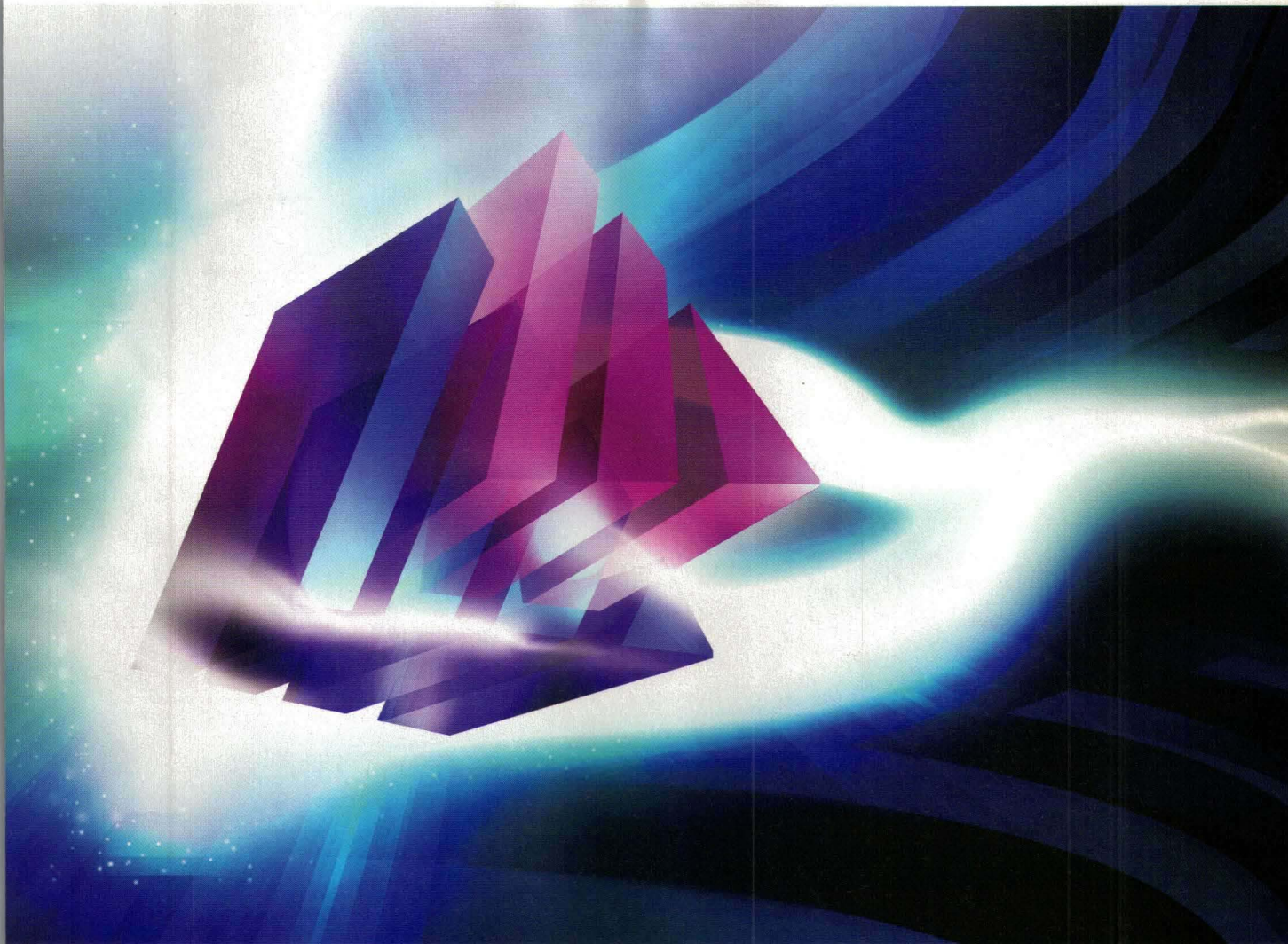
Stripline - 25 to 100 watt power						
Freq. Range (GHz)	I. L. (dB) min.	Coupling Flatness (± dB) max.	Dir. (dB) min.	VSWR max.	P/N	
0.5-1.0	0.20	0.75	25	1.20:1	CS*-01-**	
0.5-2.0	0.35	0.75	23	1.20:1	CS*-02-**	
1.0-2.0	0.20	0.75	25	1.15:1	CS*-03-**	
1.0-4.0	0.35	0.50	23	1.20:1	CS*-04-**	
2.0-4.0	0.20	0.75	22	1.15:1	CS*-05-**	
3.6-4.2	0.50	0.30	15	1.45:1	CS*-06-**	
2.6-5.2	0.20	0.75	18	1.25:1	CS*-07-**	
5.8-6.4	0.50	0.30	15	1.45:1	CS*-08-**	
2.0-8.0	0.35	0.40	20	1.25:1	CS*-09-**	
4.0-8.0	0.25	0.75	18	1.30:1	CS*-10-**	
7.2-8.5	0.50	0.30	15	1.45:1	CS*-11-**	
7.0-12.4	0.30	0.50	17	1.30:1	CS*-12-**	
7.5-16.0	0.50	0.75	12	1.40:1	CS*-13-**	
4.0-12.4	0.50	0.40	17	1.30:1	CS*-14-**	
2-12 12-18 GHz						
1.0-18.0	0.90	0.50	15 12	1.50:1	CS*-18-**	
2.0-18.0	0.80	0.50	15 12	1.50:1	CS*-15-**	
4-12 12-18 GHz						
4.0-18.0	0.60	0.50	15 12	1.40:1	CS*-16-**	
12.4-18.0	0.50	0.50	N/A 15	1.40:1	CS*-17-**	

\* Coupling Value: 6, 10, 20, 30

\*\* Connectorized Models available with SMA and "N" connectors.

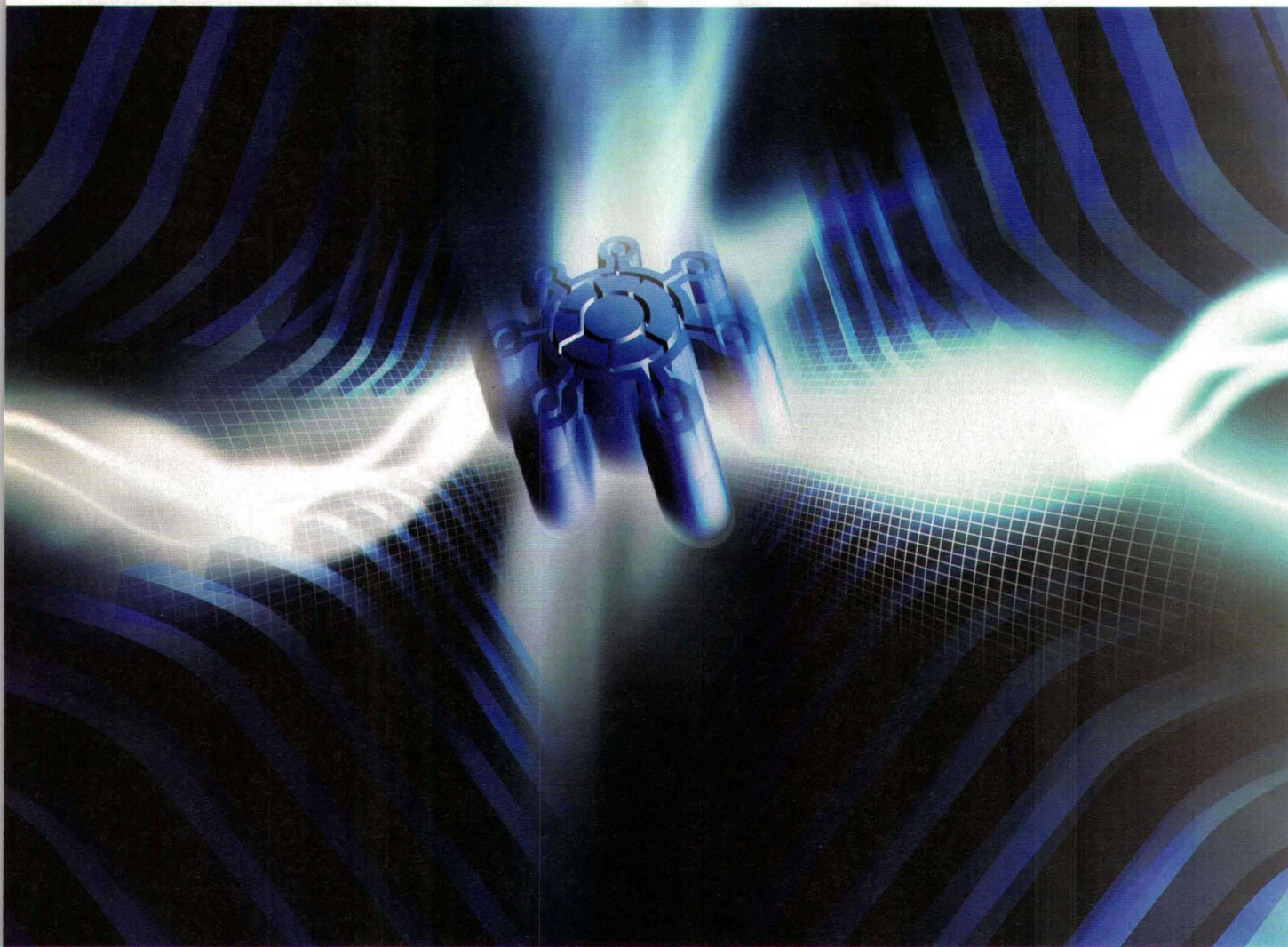
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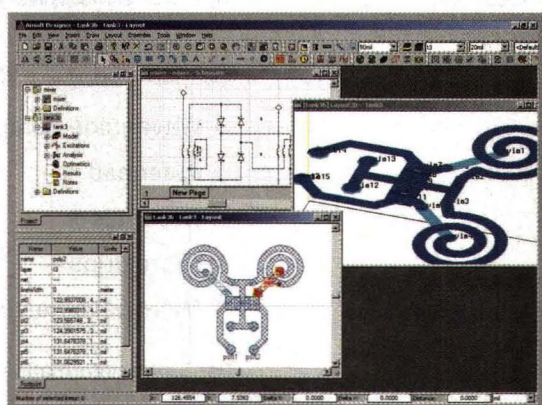
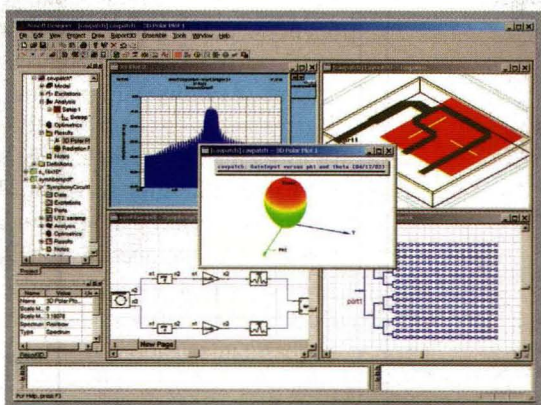
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in particular about Tality's CougarFE, an in-house personal-computer (PC)-based software program for design verification. The software supports a wide range of test gear including vector analyzers, signal generators, and power meters.

Jonathan Borrill of Anritsu Ltd.

(Luton, Bedfordshire, England) spoke on "Signaling, protocol, and measurement requirements for production testing of 3G handsets," in particular, the company's model MT8820A, a single-box measurement solution for 3GPP WCDMA handset production testing. The

single instrument combines the functionality of a spectrum analyzer, signal generator, and network simulator, with the capabilities of transmitting, receiving, and measuring all required signals.

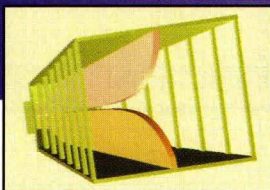
William King and Saddique Mohammed of the Telecommunications Division of Nera Ltd. (Red Hill, Surrey, England) presented their "Microwave integrated circuit for millimeter-wave high-capacity radio." The authors reviewed the general requirements for a microwave integrated circuit (MIC) that is capable of meeting minimum performance standards for high-capacity millimeter-wave radios and then presented an MIC assembly designed to meet the performance requirements for 38-GHz systems.

Nigel Wilson of Securicor Wireless Technology Ltd. (Midsomer, Norton, Bath, England), in his presentation "Linearization for EDGE," reviewed different approaches for amplifier linearization in EDGE systems, including polar linearization, feedforward linearization, and predistortion techniques. He noted that the Cartesian loop, often perceived as a narrowband technique, offers great promise for broadband linearization.

A.G. Morgan, Nick Ridler, and M.J. Salter of the NPL detailed "Generalized 'Adaptive' Calibration Schemes for VNAs," including a variety of different RF calibration schemes for one-port vector network analyzers (VNAs) in addition to the traditional short-open-load (SOL) scheme. Authors Morgan and Ridler also teamed with the NPL's R.A. Dudley to describe the NPL's iPIMMS, an Internet-based calibration service for VNAs.

The next (36th) ARMMS meeting is scheduled for October 28 and 29, 2002. The venue is still not determined. For more information on attending the meeting, or for information on obtaining technical proceedings, please visit the website at [www.armms.org](http://www.armms.org), contact the ARMMS Marketing Coordinator, JJ Heath-Caldwell, at (44) 01962-761-565, FAX: (44) 01962-761-565, e-mail: [jj@gcd.co.uk](mailto:jj@gcd.co.uk), or contact the ARMMS program coordinator, David Adamson, at (44) 20 8943 6965, FAX: (44) 20 8614 0447, e-mail: [David.Adamson@npl.co.uk](mailto:David.Adamson@npl.co.uk). **MRF**

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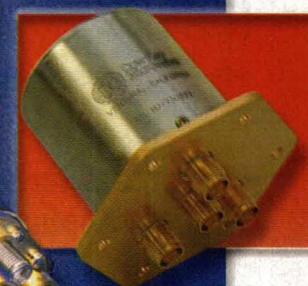
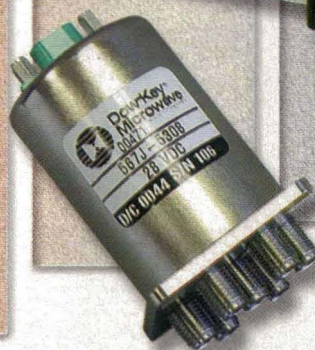


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Elcom Technologies, Inc., 11 Volvo Dr., Rockleigh, NJ 07647; (201) 767-8030 ext. 230, FAX: (201) 767-0542, Internet: [www.elcom-tech.com](http://www.elcom-tech.com).

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## Converters Target Telecom Applications

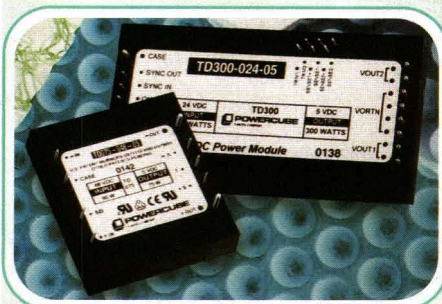
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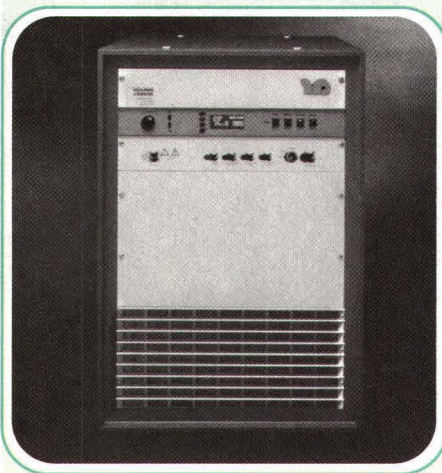
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Amplifier Research, 150 School House Rd., Souderton, PA 18964; (215) 723-8181, (215) 933-8181, Internet: [www.amplifiers.com](http://www.amplifiers.com).

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## Generator Tests SDARS-Capable Radios

MODEL CS2010SDARS IS a satellite-radio signal generator that provides an "all-in-one" solution for production testing of satellite-delivered audio radio (SDARS)-capable radios. By providing the two satellite channels and the terrestrial repeater channel simultaneously, a single generator simulates an SDARS network connection. The unit features up to 70 dB of independent signal-to-noise ratio (SNR) for each channel, 30 MHz of multi-carrier bandwidth for full-band realism, and 11.5 s of nonrepetitive signal playback. The generator can simulate adjacent channel signals, potential in-band and out-of-band interferers, and, using built-in signal-import functions, replay field-recorded drive-test signals, allowing test and validation of radios at manufacturing sites anywhere in the world. The unit is fully network compatible, making it a truly global solution.

Celerity Systems, Inc., 10411 Bubba Rd., Cupertino, CA 95014; (408) 873-1001, Internet: [www.celeritydbt.com](http://www.celeritydbt.com).

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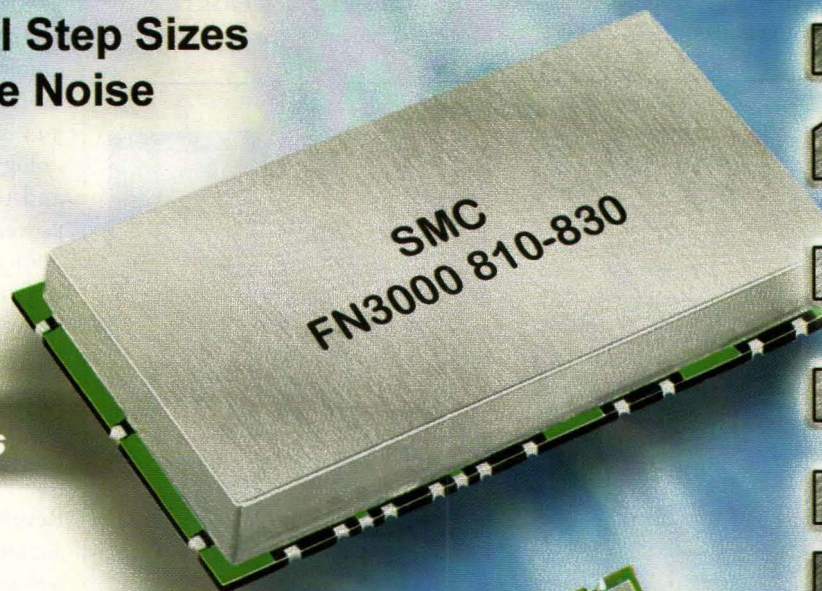
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SYNERGY

# APT To Acquire Microsemi RF

AS A LEADING supplier of high-performance power semiconductors used in the conditioning and control of elec-

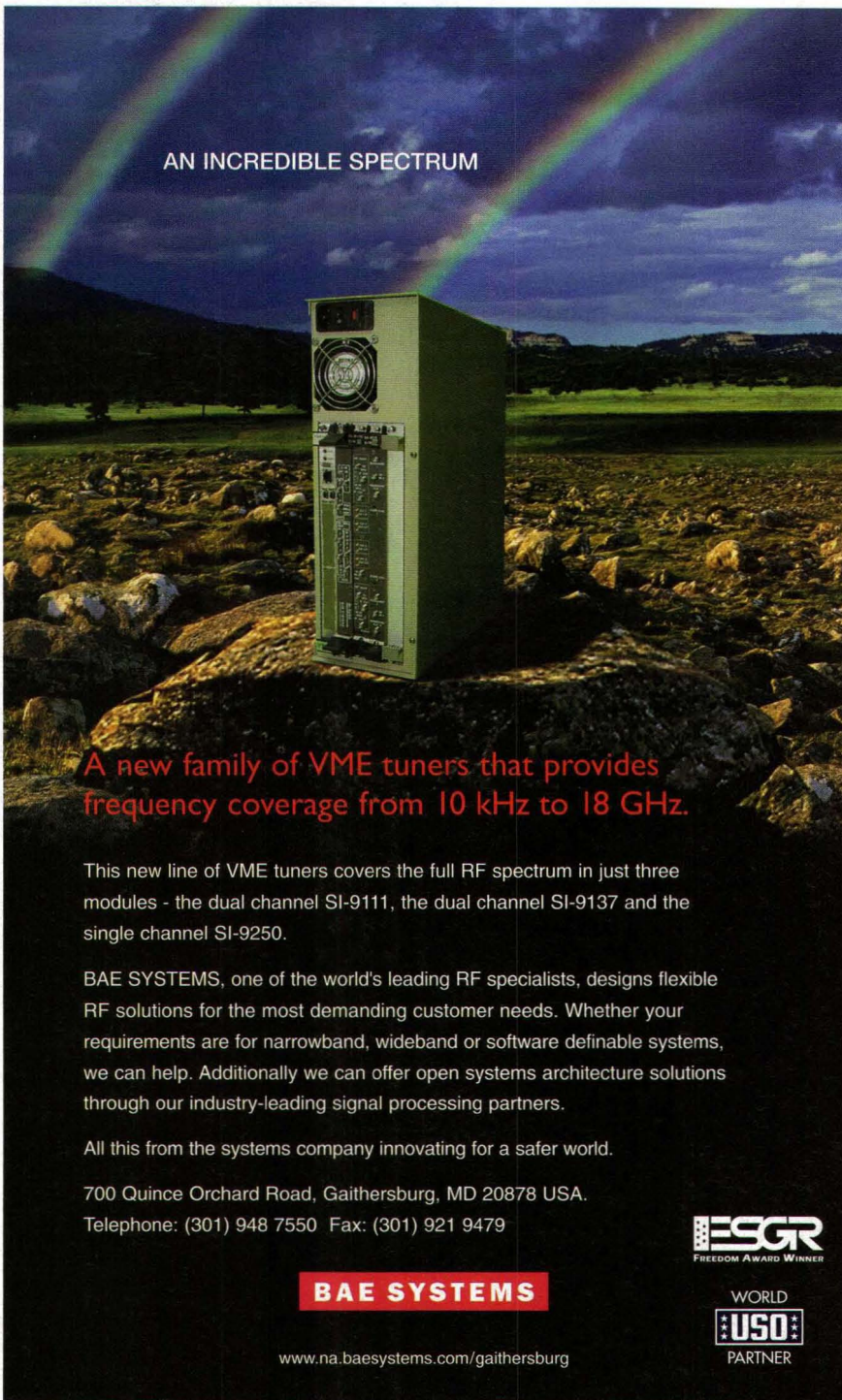
trical power, Advanced Power Technology, Inc. (Bend, OR) has recently announced that it has signed an Asset

Purchase Agreement to acquire the product lines and certain assets of Microsemi RF Products, Inc. (Montgomeryville, PA). The acquisition is worth approximately \$12.2 million and is part of Advanced Power Technology's strategy to expand its product and technology portfolio in the RF power market through internal development and acquisitions, including the recent acquisition of RF power-device manufacturer GHz Technology.

Microsemi RF Products, Inc., a wholly owned subsidiary of Microsemi Corp., produces and sells bipolar RF transistors for radar, avionics, communications, and general-purpose applications. Revenues related to the business being acquired by Advanced Power Technology were \$10.4 million over the last year. Also, over the last four quarters, the pro forma revenues of APT combined with GHz Technology and Microsemi RF were \$50.9 million, of which there was \$24 million in RF power products, or approximately 47 percent of revenue. There was also \$26.9 million in revenue with switching power products, equating to approximately 53 percent.

The transaction is expected to be immediately slightly accretive to cash earnings. It is anticipated that the closing is subject to certain customary closing conditions being met. With more than \$30 million in cash and marketable securities and no debt, Advanced Power Technology is capable of financing the acquisition with funds on hand.

Patrick Sireta, CEO of Advanced Power Technology, said, "When combined with APT's recent acquisition of GHz Technology, this transaction positions APT as an emerging dominant supplier in bipolar RF power transistors for avionics, radar, and noncellular-communications applications. I have been very impressed by the talent, dedication, and entrepreneurial spirit of Microsemi RF Products' employees and look forward to working with them in further developing APT's business." **MRF**



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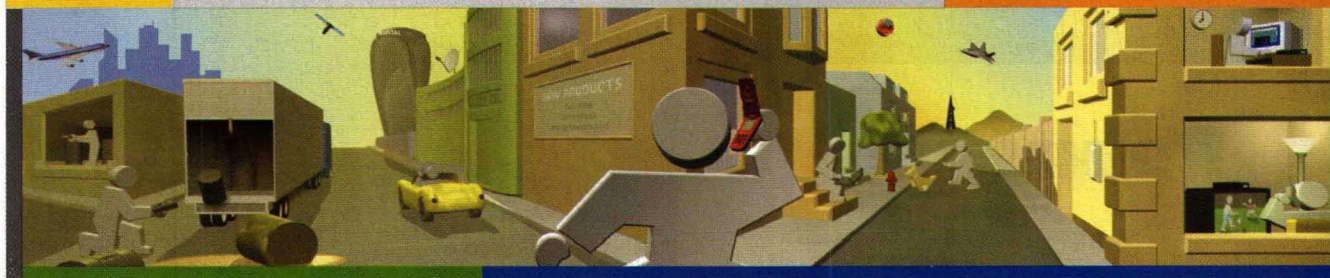
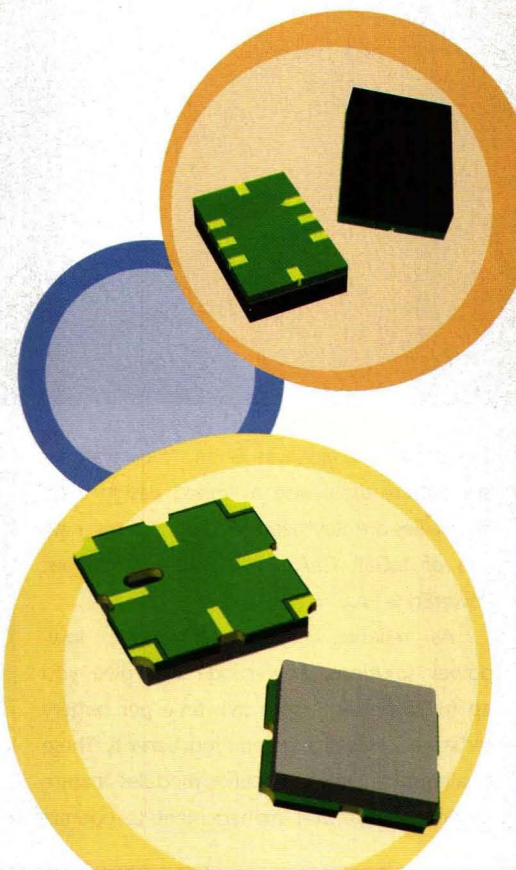
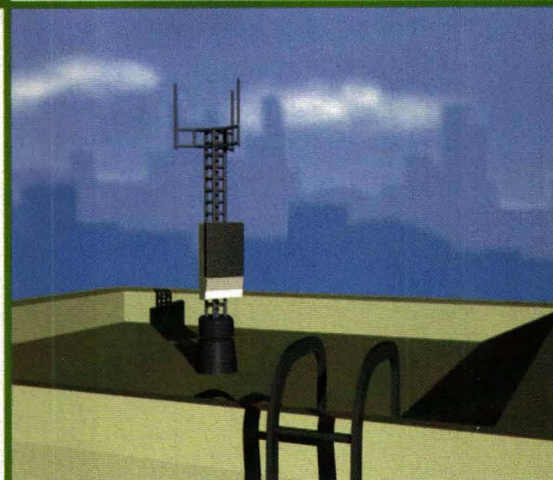
- Frequencies from 300 MHz to 2.5 GHz
- STW technology offers low phase noise (-120 dBc/Hz to -135 dBc/Hz at 10 kHz, -165 dBc/Hz at 1 MHz) and exceptional high frequency jitter performance (<5 fS RMS)



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## CONTRACTS

**EMS Technologies, Inc.**—Announced that ITT Industries, Inc. has awarded EMS a contract initially valued at \$4.2 million to equip four aircraft with advanced radar-jamming functions as part of the new ALO-211 Suite of Integrated RF Countermeasures (SIRFC) system. The US Army and Air Force developed the SIRFC electronic protection system for rotary wing aircraft. The system is scheduled for deployment on several Army and US Air Force platforms, including the AH-64D Apache Longbow, Special Operations MH-60K and MH-47E, RAH-66 Comanche, and the CV-22 Osprey. The EMS contract follows a \$2.9 million contract announced in July 2001 for engineering work necessary to prepare for hardware production.

**Wide Band Systems, Inc.**—Has been awarded a \$9.65 million contract by the Naval Surface Warfare Center, Crane Division, Crane, IN for production of AN/WLR-1H(V)7 Countermeasure Receiving Set modification kits.

**Wireless Telecom Group, Inc.**—Announced that its wholly owned subsidiary, Boonton Electronics, has received an order from the US Navy for its 1121 Audio Analyzers. These orders are for approximately \$500,000 and were scheduled to ship in the second quarter of this year.

**Motorola**—Has been announced as the recipient of a contract from TA Orange worth \$253 million to provide a GSM1800 network in Thailand. Under terms of the agreement, Motorola's Global Telecom Solutions Sector (GTSS) will supply radio-access equipment and related installation and integration services for the turnkey system, which is already being deployed throughout Thailand's northern, northeastern, and eastern provinces.

**Poynting Antennas (Pty) Ltd.**—Secured a contract for an S.T.V. system for the Central Bank Nigeria, Head Office Complex in Abuja, Nigeria. The project entails: the design of the system; the sourcing, assembly, and checking of the equipment in South Africa; installing the system; and concluding with the testing and commissioning of the system. The system will then be handed over to the client.

**NetCom Solutions, Inc.**—Has received a contract from the Pepsi Bottling Group, Inc. (PBG) to provide them with a warranty administration program for Pepsi's fleet. The total warranty administration will allow PBG to process claims in a timely manner in order to maximize recovery funds during the warranty period. NetCom Solutions intends to collect the previous six months of data to ensure that claims were processed and warranty monies were claimed.

## FRESH STARTS

**Wireless Valley Communications, Inc.**—Has moved its headquarters from Blackburg, VA to Austin, TX. All e-mail

addresses will remain the same, as will the website URLs. The telephone number in Austin is (512) 821-1560. The fax number is (512) 821-1585. All phone extensions will remain the same. The street address is: Wireless Valley Communications, Inc., 2404 Rutland Dr., Suite 700, Austin, TX 78758. Wireless Valley requests that the street address be used for shipping all packages, magazines, catalogs, and flyers. The mailing address for all non-package mail is: Wireless Valley Communications, Inc., P.O. Box 81664, Austin, TX 78708-1664.

**Filtel Microwave, Inc.**—Has made the following representative appointments recently: John Libby for New England; Pamcor, Inc. for Southern California; Sincron SRL for Italy; and Tactron GmbH for Germany. In addition, Filtel has established a new website at [www.filtel.com](http://www.filtel.com). The website describes Filtel's capabilities in high-performance design and low-cost manufacture of cavity filters and diplexers up to 40 GHz.

**Amcom Communications**—Changed its website to include the new corporate profile, new products, and options including easier access to data sheets. There is also a complete listing of all global sales representatives. The website's URL is [www.amcomusa.com](http://www.amcomusa.com).

**Intercept Technology, Inc. and Trident Techlabs Pvt. Ltd.**—Announced a distribution agreement for Intercept's PCB/Hybrid/MCM software applications, including the PANTHEON product family and the MOZAIX schematic capture application. The distribution agreement allows Trident to sell licensed PANTHEON and MOZAIX software applications, related technical support, and maintenance to customers in India. Trident will provide support on-site and by telephone. The distribution agreement enables Intercept to offer the advanced capabilities of MOZAIX and PANTHEON to a wider user base in India. The agreement will strengthen Intercept's global sales force and expand the company's presence in the international EDA community.

**Intersect, Inc.**—Has been founded in Kennesaw, GA. The company specializes in offering custom-configured panels for the telecommunications industry. Mary L. Munger is the president of Intersect. The firm's website can be found at [www.intersectinc.biz](http://www.intersectinc.biz).

**Cornell Dubilier Electronics, Inc.**—Announced that it has acquired the Distributor Division of North American Capacitor Co.'s Mallory Products Group from a subsidiary of Vishay Intertechnology, Inc.

**Linear Technology Corp.**—Opened its eighth design center in Burlington, VT. The center is staffed with eight experienced IC designers with over 104 years of combined experience. The engineering team at the design center will quickly provide additional product capability.

**TDK Semiconductor Corp.**—Completed a major upgrade to its existing website. The upgraded website includes complete product information, with PDF files that are easily downloadable. The site is located at [www.tdksemiconductor.com](http://www.tdksemiconductor.com). **MRF**

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## people



MALLORY

## Mallory Is Appointed As 3M National Sales Manager

3M Optical Components has named NANCY MALLORY to the position of national sales manager and key account manager for the Southeast region. Mallory has been with 3M since 1989 in various sales and marketing positions.

**TSCI Corp.**—KENNETH ELMER to president and CEO; formerly CFO.

**REMEC, Inc.**—DAVE NEWMAN to vice president and general manager of the Radio Products business unit of REMEC Broadband Wireless; formerly vice president of business operations for DMC Stratex Networks.

**Southampton Photonics (SPI)**—DR. DAVID PARKER to president and CEO; formerly president and CEO of Marconi Optical Components (MOC).

**Institute of Electrical and Electronics Engineers (IEEE) Antennas and Propagation Society (AP-S)**—DR. ZOLTAN CENDES to distinguished lecturer; continues as chairman and chief technology officer at Ansoft Corp.

**ARC Technologies**—ROBERT L. WELCH to vice president, international; formerly employed in sales and marketing management positions with Schlegel Systems, Inc.

**Applied Wave Research, Inc. (AWR)**—MARK SHUFFIELD to the position of western regional sales director; formerly global account manager (Qualcomm) for Agilent Technologies.

**Horizon PCS, Inc.**—ALAN G. MORSE to COO; formerly COO at TelePacific Communications, Inc.

**Optical Cable Corp.**—CRAIG H. WEBER to the board of directors; remains as president of Whitlockebs.

**Zetex**—FRANK MANDARINO to distribution manager for the Americas; formerly employed with Infineon.

**IPC**—PAUL ENGSTROM to director of communications; formerly public relations director for the US Navy's Smart Card group for Unified Industries, Inc.

**Radiant Networks plc**—GEOFF BUTCHER to CEO; formerly CEO of Protek.

**E2O Communications, Inc.**—DALE BARTOS to COO/CFO; formerly headed the finance and operations departments at Mirapoint, Inc. Also, ROBIN L. CRANDELL to senior vice president of worldwide sales; formerly an ownership partner at Phase II Technical Sales, Inc.

**Touch America**—MARY GAIL SULLIVAN to vice president for customer development; formerly director of auditing and risk management.

**ASTM Electrical Conductors Committee**—GORDON C. BAKER to chairman of the ASTM Committee B01 on Electrical Conductors; continues as managing engineer at General Cable Industries.

**ITT Industries, Avionics Division**—MARK CHUBIK to vice president and controller; formerly Value Based Six Sigma (VBSS) Champion for ITT Industries' Night Vision.



CHUBIK



WRIGHTSON

**Link Microtek Ltd.**—KEVIN WRIGHTSON to calibration and service engineer; formerly employed as quality and calibration technician at Gems Sensor.

**Day**—ROY T. FIELDING, PH.D. to the position of chief scientist; continues as member of the W3C Technical Architecture Group. **MRF**

# Amplifiers

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## Broadband, Small Signal

Model Number	Frequency Range (Ghz)	Gain (dB Min)	Gain Flatness (±dB Max)	Noise Figure (dB Max)	VSWR Input Port Max	VSWR Output Port Max	Output Power @ 1dB CP (dBm Min)	DC Input Current Vdc: +12 (mA Typ)
CMA2080A1	2.0-8.0	30	1.5	6	2:1	2:1	+15	200
CMA20120A	2.0-12.0	33	2.0	6	2:1	2:1	+15	350
CMA20180A	2.0-18.0	34	2.0	6	2:1	2:1	+18	450
CMA60180A1	6.0-18.0	36	1.5	6	2:1	2:1	+15	350
CMA180265A	18.0-26.5	30	1.5	6	2:1	2:1	+16	400
CMA265400A	26.5-40.0	30	1.5	6	2:1	2:1	+16	400

## Broadband, Low Noise

CMA60180A2	6.0-18.0	30	1.5	3	2:1	2:1	+10	200
CMA180265A1	18.0-26.5	30	1	3	2:1	2:1	+10	200
CMA265400A1	26.5-40.0	28	1.5	3.5	2:1	2:1	+10	200

## Medium Power

CMA5964B10	5.9-6.4	40	1.0	8	1.5:1	1.5:1	+33	1500
CMA5971B1	5.9-7.1	20	1.0	10	1.8:1	1.8:1	+33	1500
CMA7185B2	7.1-8.5	20	1.0	10	1.8:1	1.8:1	+33	1500
CMA85125B1	8.5-12.5	30	1.5	8	2:1	2:1	+35	3000
CMA107117B2	10.7-11.7	20	1.0	10	1.8:1	1.8:1	+33	2000
CMA127132B	12.7-13.2	40	1.0	5	1.8:1	1.8:1	+34	4000
CMA137145B	13.7-14.5	45	1.0	6	1.5:1	1.8:1	+33	1500
CMA142153B6	14.2-15.3	15	1.0	8	1.5:1	1.8:1	+30	1000
CMA177197B15	17.7-19.7	35	1.0	8	1.5:1	2:1	+30	1100
CMA181186B17	18.1-18.6	34	0.5	10	1.5:1	1.5:1	+33	3000
CMA200230B1	20.0-23.0	10	1.0	12	1.5:1	2:1	+30	1000
CMA295297B1	29.5-29.7	20	0.3	10	1.5:1	1.8:1	+30	1000

## High Power

CMA1616B	1.6-1.68	45	0.25	10	2:1	2:1	+43	8500
CMA4450B27	4.4-5.0	40	1.0	8	1.5:1	1.5:1	+43	11000
CMA5964B40	5.9-6.4	40	1.0	8	1.5:1	1.5:1	+43	12000
CMA127132B7	12.7-13.2	40	1.0	8	1.5:1	1.5:1	+43	20000
CMA137145B19	13.7-14.5	53	1.0	6	1.5:1	1.5:1	+43	22000

## TWT/KPA Drivers, Linearized Gain Control

Model Number	Frequency Range (Ghz)	Gain (dB Min)	Gain Flatness (±dB Max)	Noise Figure (dB Max) @ 0 Gain Control	VSWR In/Out Max	Gain Control (dB Max)	Output Power @ 1dB CP (dBm Min)	DC Input Current Vdc: +12 (mA Typ)
CMA5866A13	5.8-6.6	30	1.0	7	1.4:1/1.3:1	25	+13	260
CMA7984A1	7.9-8.4	30	1.0	7	1.4:1/1.3:1	25	+13	260
CMA127145A6	12.7-14.5	35	1.5	7	1.4:1/1.3:1	25	+18	500
CMA173184A8	17.3-18.4	38	1.0	7	1.4:1/1.3:1	25	+20	500
CMA270310A4W/G	27.0-31.0	20	1.0	10	1.5:1/2.0:1	25	+20	500

Note: Gain control voltage range is 0 to +10 Vdc (Maximum gain @ +10 Vdc)

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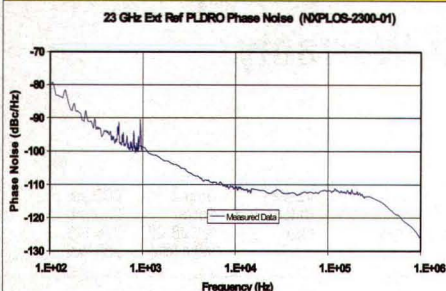
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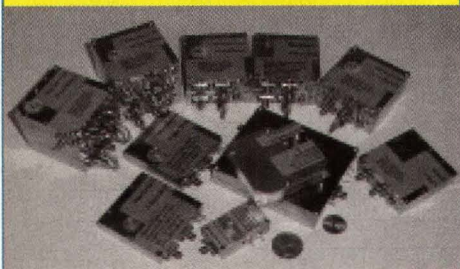
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August 12-14 (Madison, WI)  
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e-mail: [danbeck@epd.engr.wisc.edu](mailto:danbeck@epd.engr.wisc.edu)  
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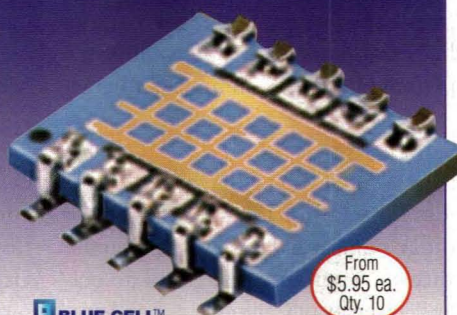
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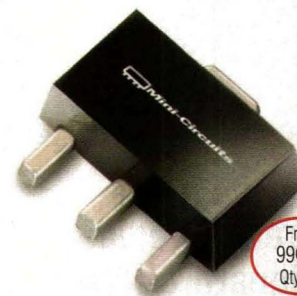
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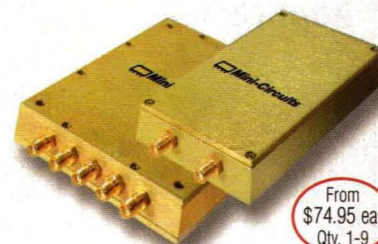
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## Method Improves Downconverter Performance

DOWNCONVERTER CONVERSION-GAIN performance can be dramatically improved through analysis, according to researchers T. Brabetz and V.F. Fusco of The Queen's University of Belfast (Belfast, Northern Ireland). By analyzing a millimeter-wave, single-ended PHEMT gate-mixer frequency downconverter, the researchers discovered the influence of viahole inductance on conversion-gain performance. By reducing the effect of feedback inductance as a voltage divider, the researchers were able to improve conversion gain by 3.5 dB, compared to clas-

sical topologies operating at 65.3 GHz with a nominal intermediate frequency (IF) of 1.3 GHz. Rather than trying to achieve a wafer thinness of near zero, the researchers discovered it was not necessary to short circuit all source terminals to ground for all frequencies, only for the RF and local oscillator (LO) and frequencies. For more information on the downconverter, see "Millimeter-Wave Down-Converter Conversion Gain Performance Enhancement," *Microwave and Optical Technology Letters*, March 20, 2002, Vol. 32, No. 6, p. 399.

## Predict Radar Signatures From Computed EM Data

PREDICTING RADAR SIGNATURES from electromagnetic data is vital for the development of accurate radar signature databases, especially for large targets. Yuanxun Wang and associates from the University of California at Los Angeles (Los Angeles, CA) have developed a radar-cross-section (RCS) interpolation method that

can efficiently predict radar signatures from computational EM data. For more information, see "Efficient Radar Signature Prediction Using a Frequency-Aspect Interpolation Technique Based on Adaptive Feature Extraction," *IEEE Transactions on Antennas and Propagation*, February 2002, Vol. 50, No. 2, p. 122.

## Broadband Printed Antennas Feed Millimeter-Wave Applications

MILLIMETER-WAVE FREQUENCIES hold great potential for broadband communications systems. Before low-cost broadband services, such as local-multipoint-distribution-service (LMDS) systems, can be offered to the general public, however, practical millimeter-wave components, such as antennas, must become a reality. Rod Waterhouse and researchers at the Australian Photonics Cooperative Research Centre of the School of Electrical & Computer Systems Engineering at RMIT University (Melbourne, Australia) offer a technique for reducing the back radiation of broadband millimeter-wave printed-antenna arrays by using specially designed reflector patches. With this approach, the front-to-back ratio of an antenna array can be improved by 30 dB over the 26 to 40 GHz band, making these antenna arrays suitable for

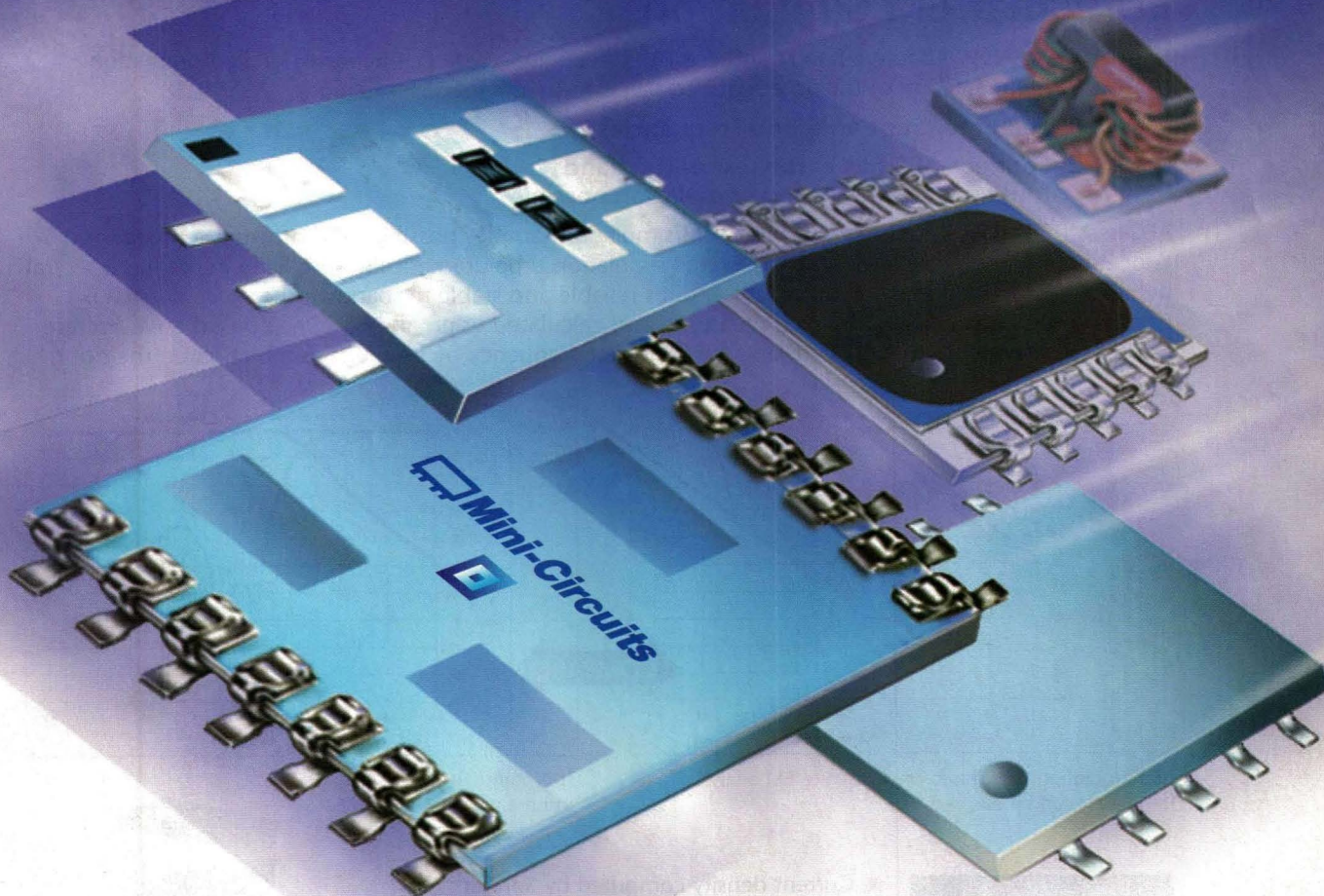
sectorized coverage in millimeter-wave systems. The antenna consists of an eight-element linear aperture-stacked-patch (ASP) array with eight corresponding back patches. A reflector patch is located on the feed side of the antenna ground plane. The reflector-microstrip patch is separated from the feedline by a laminate material with low dielectric constant to ensure that surface losses are kept to a minimum. The dielectric material can be any thickness, but is typically used in an electrically thick configuration to minimize direct coupling between the patch and the feedline. For more information about the approach, see "Broadband Printed Sectorized Coverage Antennas for Millimeter-Wave Wireless Applications," *IEEE Transactions on Antennas and Propagation*, January 2002, Vol. 50, No. 1, p. 12.

## PBG Circuits Aid Performance of Substrate Patch Antennas

MICROSTRIP PHOTONIC BANDGAP (PBG) circuits can be used to enhance the performance of high-density substrate patch antennas. The approach is detailed by Andrey Andrenko and associates from the Mobile Communications Development Laboratories of Fujitsu Laboratories Ltd. (Yokosuka, Japan) and the Information Technology R & D Center of Mitsubishi Electric Corp. (Kanagawa, Japan). Through the use of electromagnetic (EM) software simulators, the researchers show that the use of the PBG circuits in an active integrated antenna

eliminated higher-order frequency harmonics and patch radiation modes, and improved the return-loss performance of the antenna at fundamental-mode frequencies. Optimization of the PBG periodic element geometry can provide further harmonic filtering in a wide frequency bands of operation. For more information, see "Application of PBG Microstrip Circuits for Enhancing the Performance of High-Density Substrate Patch Antennas," *Microwave and Optical Technology Letters*, March 5, 2002, Vol. 32, No. 5, p. 340. **MRF**

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2	0	SBB	5	800-2300	22-24	0.5-0.6	3.0-4.0	4.95
2	90	QBA	7	340-2400	21-28	0.25-0.80	3.0-7.0	6.95
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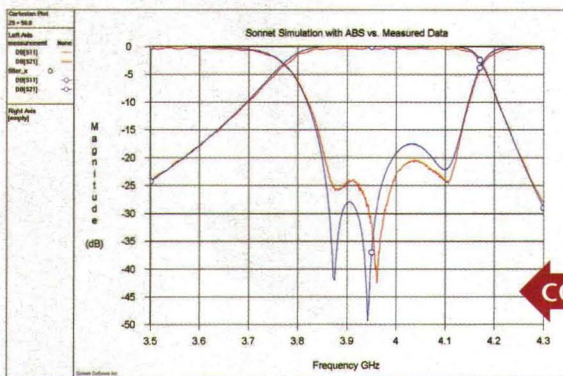
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## Adaptive Band Synthesis for 3D Planar EM Simulation

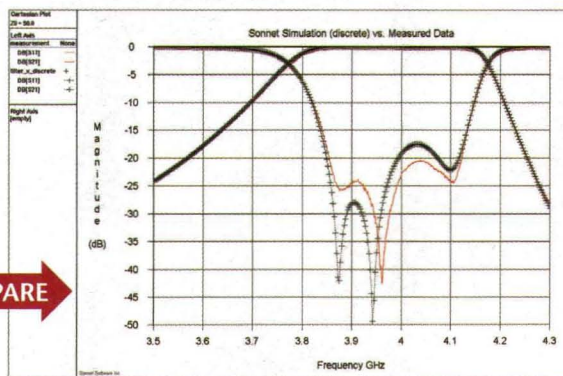
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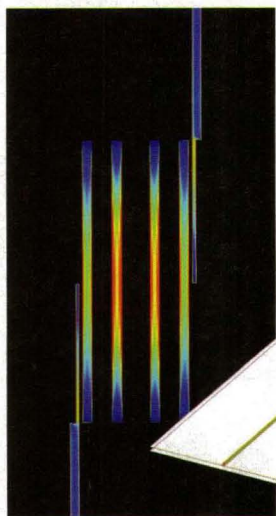


ABS simulation data based on 4 discrete EM analysis frequencies and measured data



300-point Discrete EM analysis and measured data

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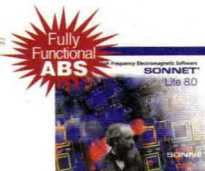
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# Increase MMIC Yield With Statistical Design

By accounting for the effects of process variations through the use of modern computer-aided statistical-analysis tools, MMIC yields can be raised to levels approaching 100 percent in many cases.

**P**rocess variations can transform the most innovative monolithic-microwave-integrated-circuit (MMIC) design into a failure. To account for these variations, designing for high manufacturing yield is as important as designing for good electrical performance. What follows is an examination of a new microwave-circuit design process based on advanced statistical methods that can help improve the yield of

with a high manufacturing yield.

When the goal for a MMIC design is high yield, it should be based on a robust design that is insensitive to variations in the manufacturing process. Although the statistical methods described in this article entail an up-front investment in setup and analysis, the payoff is better results. Designing a circuit without going through essential statistical design steps can result in higher research-and-development (R&D) costs associated with fabrication trials and design iterations.

## JACK SIFRI

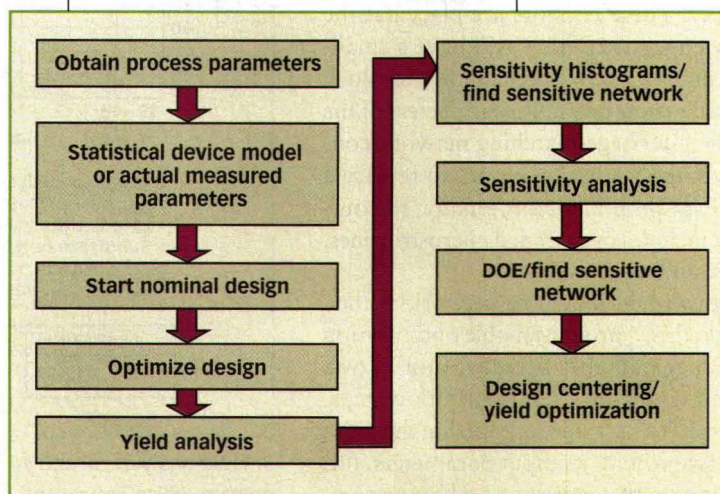
Product Manager for RFIC Circuit Simulation

Agilent EESof EDA, 5601 Lindero Canyon Rd., Westlake Village, CA 91362; (818) 879-6235, FAX: (818) 879-6346, e-mail: jack\_sifri@agilent.com, Internet: www.agilent.com/find/eesof.

the most sophisticated MMICs. The design methodology will be demonstrated with a step-by-step analysis of an X-band MMIC amplifier. Techniques include programmable optimization, sensitivity analysis, design centering or yield optimization, and design of experiments (DOE). Final simulations will show that, if properly modeled, the amplifier design can be made insensitive to process variations

be based on a robust design that is insensitive to variations in the manufacturing process. Although the statistical methods described in this article entail an up-front investment in setup and analysis, the payoff is better results. Designing a circuit without going through essential statistical design steps can result in higher research-and-development (R&D) costs associated with fabrication trials and design iterations.

1. The design process for improved MMIC yield includes statistical analysis and yield optimization.



**Figure 1** outlines the design process that is used to design an X-band low-noise-amplifier (LNA) MMIC. After the initial design phase, statistical design tools are used to examine and modify the design. It is up to the designer to choose which statistical-analysis tools to use,

although more analysis results in a greater understanding of the MMIC design.

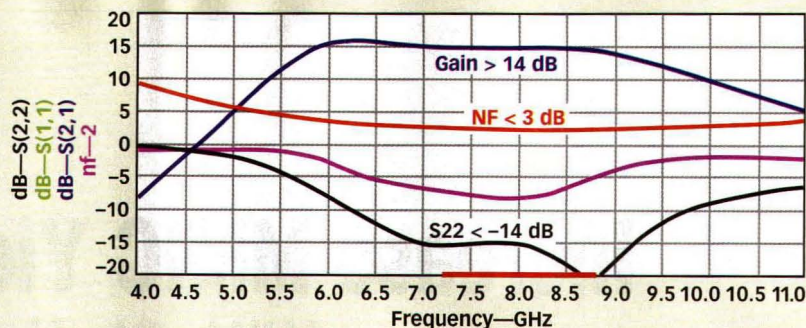
First, the process parameters are required. Knowing how the capacitors, resistors and line widths vary within the foundry process is necessary for the simulation and analysis. Second, a good model for the transistors used in the MMIC process must be obtained from the foundry. Sometimes actual measured data from wafers in different lots is available. Using this actual data is the best way to design, although it might also be possible to create an equation or series of equations that act as a statistical model of the variations in the devices. In this example, however, actual measured field-effect-transistor (FET) data is used. To start the initial design of the LNA, a good representative device from the samples is chosen.

The specifications for the LNA include a 20-percent bandwidth centered at 8 GHz (7.2 to 8.8 GHz), better than 14-dB gain, less than 3-dB noise figure, and output return loss of better than -14 dB. The top-level design has three main blocks with FET transistors between the blocks. The first block is the input-matching network. The middle block is the interstage-matching network. The block on the far right side is the output-matching network. The FET transistors also have stability resistors and structures for biasing and stability.

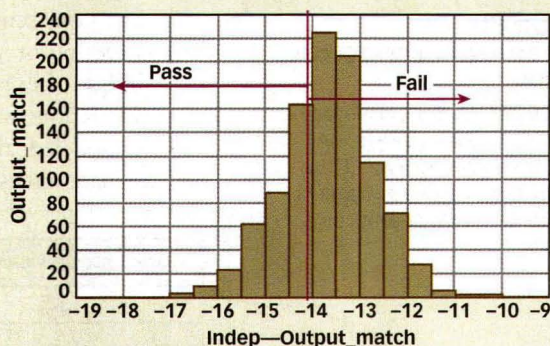
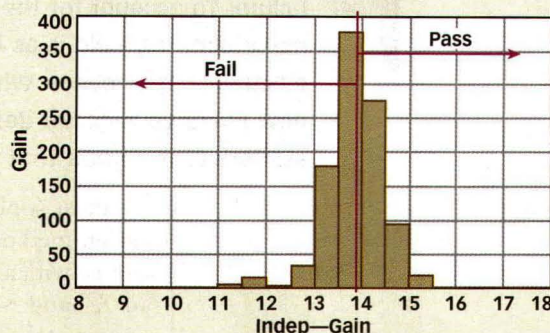
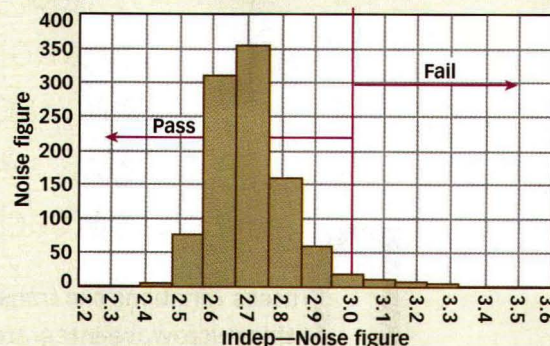
Process parameters from the foundry include 5-percent Gaussian variation in lumped elements (resistors and capacitors). Microstrip line widths vary by  $\pm 0.5 \mu\text{m}$ , and the substrate height has a  $\pm 3\text{-}\mu\text{m}$  variation from the nominal 100  $\mu\text{m}$ . The substrate dielectric constant varies  $\pm 5$  percent. For the transistors, 42 different samples with measured scattering (S)-parameters and noise parameters from different wafers within the lot were used.

The input-matching network for this MMIC design includes microstrip lines, microstrip tees, capacitors, and resistors. The input-matching network is connected to the first FET structure, with resistors at its output for mid- and high-frequency stability. These resistors are placed at the output, after the gain stage, where they will have a smaller effect on the noise figure. A two-port data access block is used to read the S-parameters and noise parameters of the 42 different FETs. The interstage-matching network consists of microstrip lines, tees, capacitors, and, to replace a long transmission line, a spiral inductor. Finally, the output-matching network includes open-ended microstrip lines, series microstrip lines, and capacitors.

This nominal design with its matching networks is then optimized (Fig. 2). To do this, a programmable optimization procedure is used. Programmable optimization allows designers to order and configure the optimization steps. This LNA is programmed to first start optimizing the noise figure on the input network with its input parameters, followed by an optimization on the interstage and output net-



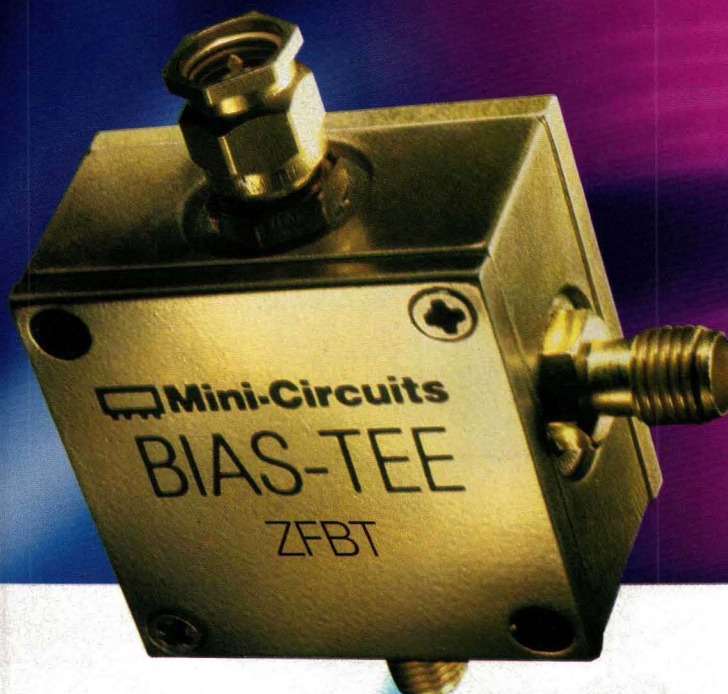
2. Amplifier performance can be dramatically improved after optimization.



Statistical analysis of LNA performance:  
 • 5-percent Gaussian variation in lumped  
 • Line widths vary  $\pm 1/2 \mu\text{m}$   
 • Substrate height 100  $\mu\text{m} \pm 3 \mu\text{m}$   
 • Substrate Er 12.9  $\pm 5$  percent  
 • 42 FET samples

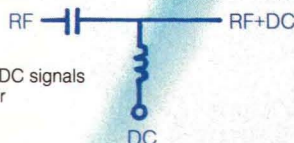
NumFail	NumPass	Yield
912.00	88.00	8.80

3. Yield analysis for the initial (optimized) LNA design focused on gain, noise figure, and output matching.



# BIAS TEES

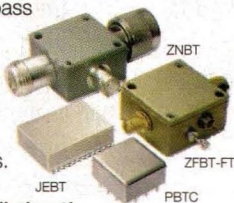
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▲ZFBT-4R2GW	0.1-4200	0.15	0.6	0.6	25	40	50	1.13:1	79.95
▲ZFBT-6GW	0.1-6000	0.15	0.6	1.0	25	40	30	1.13:1	69.95
▲ZFBT-4R2G-FT	10-4200	0.15	0.6	0.6	N/A	N/A	N/A	1.13:1	59.95
▲ZFBT-6G-FT	10-6000	0.15	0.6	1.0	N/A	N/A	N/A	1.13:1	79.95
▲ZFBT-4R2GW-FT	0.1-4200	0.15	0.6	0.6	N/A	N/A	N/A	1.13:1	79.95
▲ZFBT-6GW-FT	0.1-6000	0.15	0.6	1.0	N/A	N/A	N/A	1.13:1	69.95
★ZNBT-60-1W	2.5-6000	0.2	0.6	1.6	75	45	35	1.35:1	82.95
■PBTC-1G	10-1000	0.15	0.3	0.3	27	33	30	1.10:1	25.95
■PBTC-3G	10-3000	0.15	0.3	1.0	27	30	35	1.60:1	35.95
■PBTC-1GW	0.1-1000	0.15	0.3	0.3	25	33	30	1.10:1	35.95
■PBTC-3GW	0.1-3000	0.15	0.3	1.0	25	30	35	1.60:1	46.95
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●JEBT-6G	10-6000	0.15	0.7	1.3	32	40	40	-	59.95
●JEBT-4R2GW	0.1-4200	0.15	0.6	0.6	25	40	40	-	59.95
●JEBT-6GW	0.1-6000	0.15	0.7	1.3	25	40	30	-	69.95

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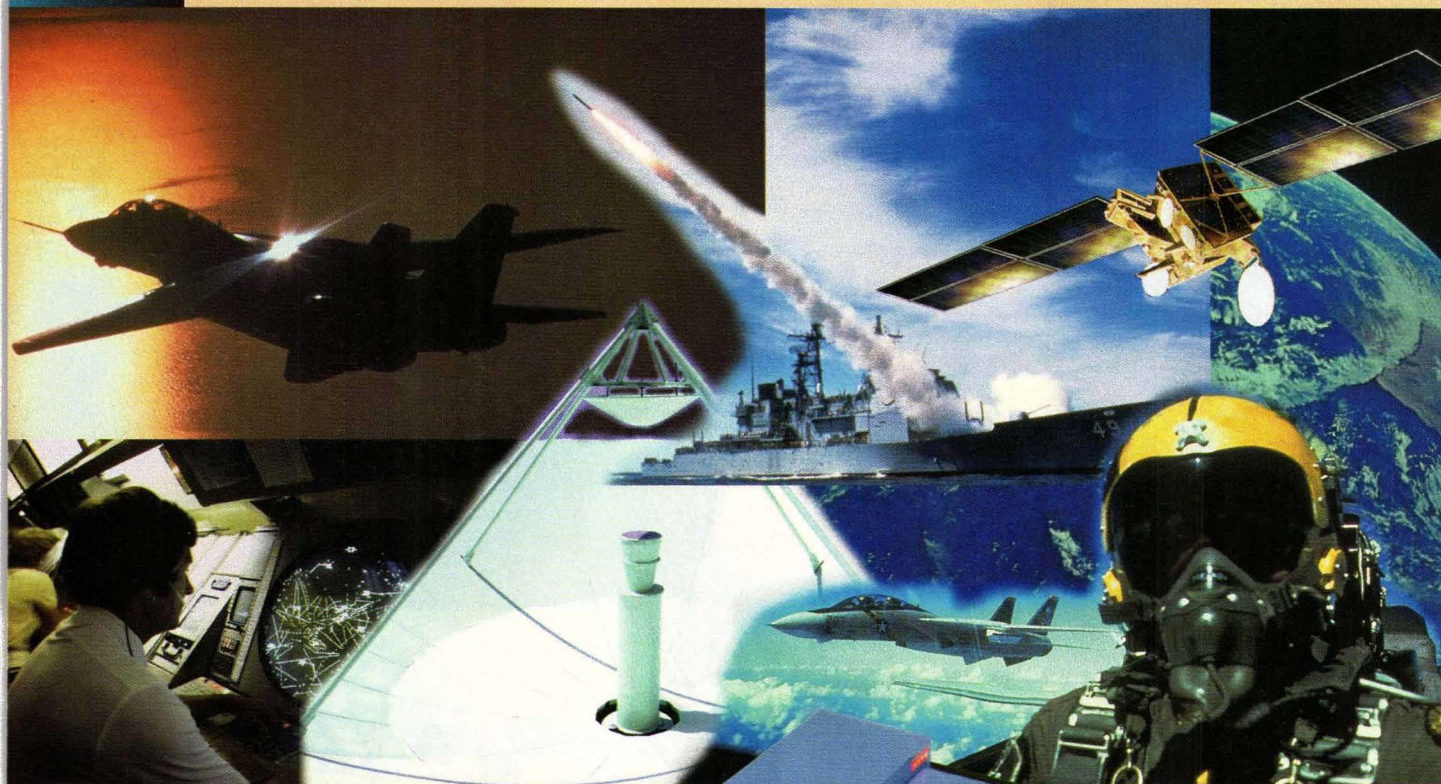
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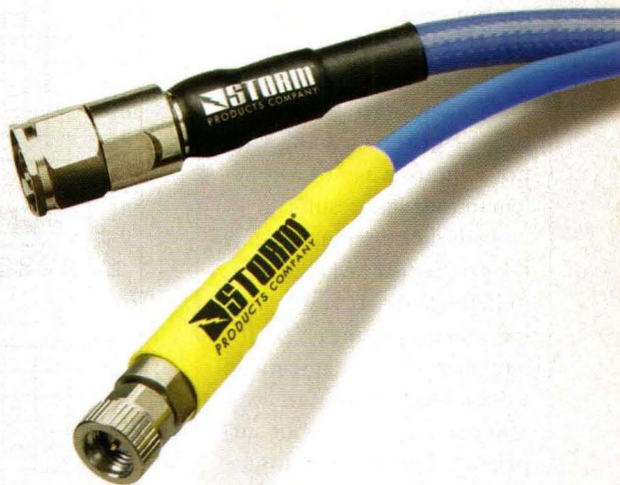
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works for gain, flatness, and output match. Finally, an overall final optimization on the whole LNA specification is performed.

After optimization, the performance criteria were met. Figure 2 shows the results after optimization. The gain is greater than 14 dB, the noise figure is less than 3 dB, and the output return loss ( $S_{22}$ ) is less than -14 dB. This design appears to be good—it even has an over-designed frequency bandwidth.

The next step in the process is to perform a Monte Carlo yield analysis. This analysis was set up to perform 1000 trials using the process variations that were described earlier. Figure 3 shows a resulting yield of only 8.8 percent. Obviously, this is a very sensitive design with a poor yield.

The results in Fig. 3 show the number of failures for gain, noise figure, and output match. There are many failures in the output-matching specification, and one-half of them fail to meet the gain specification. Only a few failed to meet the noise figure, showing that noise figure was not a problem in the yield results.

In the first attempt to locate the problem areas, the input-matching network was varied, and everything else in the amplifier was kept at nominal values. The resulting yield was 100 percent. This is not surprising, because the input-matching network mainly affects noise figure, and the first yield analysis showed that noise figure was not a problem. The next step, varying only the interstage-matching network, also achieved 100-percent yield. When only the output-matching network was varied, however, the yield dropped to 70 percent. This is

a clue that the output-matching-network design is not as robust as the interstage- and input-matching networks. This is one place to look for

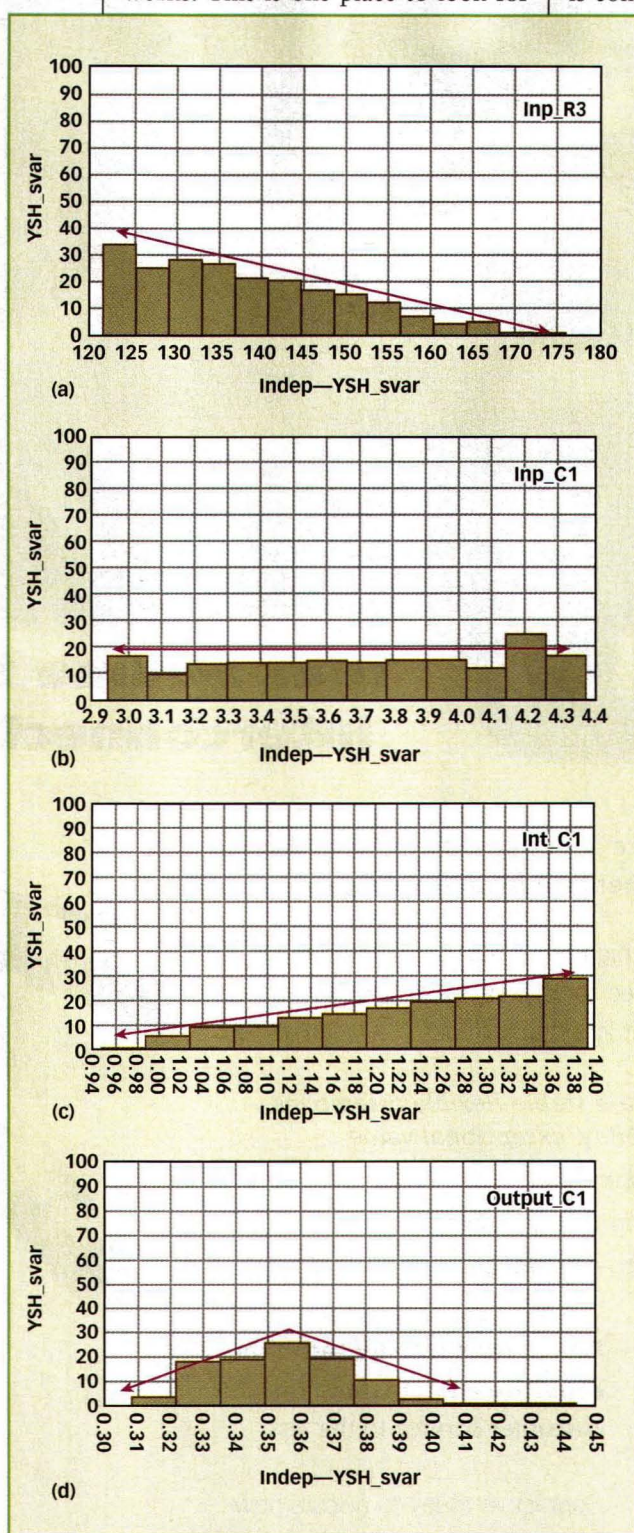
components that are sensitive to process variations.

All the data from the yield analysis is collected and stored in a data set.

Yield-sensitivity histograms are plots for helping designers to locate and fix problematic and sensitive parts of the circuit. They make it possible to examine the whole amplifier with respect to the yield of each element in the design.

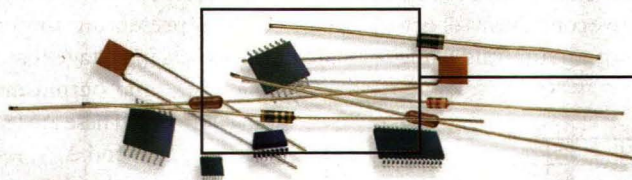
For example, Fig. 4 shows the effects on yield of four different elements: resistor FET2\_R3 and capacitors Inp\_C1, Int\_C1, and Out\_C1. Figure 4a clearly indicates that the overall LNA yield would increase if the nominal value of resistor R3 were reduced. This process, which moves the nominal values of the components right or left to increase the overall yield, can be automated using “design-centering” techniques (which will be described and used later).

Figure 4b indicates that capacitor C1 in the input-matching network is not sensitive and its variation around its nominal value does not affect the yield. Figure 4c clearly indicates that the overall LNA yield will increase if the nominal value of C1 in the interstage network is increased. The histogram plotted in Figure 4d is especially interesting. It has a maximum value at the center, with the yield dropping to zero when the nominal value is moved either right or left. This is capacitor C1 at the output of the output-matching network, which was noted earlier. The plot shows that this component has a large effect on the yield of the design. These components are known as “Red X” components and they must not be allowed to vary. In a board-level design, this capacitor could be speci-

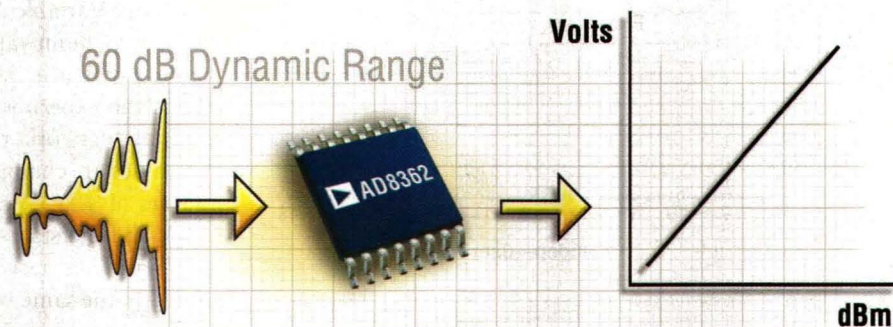


4. Yield-sensitivity data examined the effects of four variables: input resistor R3 (a), input-stage capacitor C1 (b), interstage capacitor C1 (c), and output-stage capacitor C1 (d).

# Power measurement in multiple components.



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fied for a tighter tolerance. In MMIC designs, however, variation in a capacitor's value is determined by the semiconductor process. As a result, if variations in C1 are limiting MMIC yield, the matching network must be redesigned to accommodate the limitations of the process.

Statistical analysis of yield versus each individual component and its variation has identified which components are affecting the yield. The yield-analysis histogram of capacitor C1 in the output-matching network shows that C1 is a major cause of the low yield. Of course, an experienced designer may be able to modify the output-matching network or replace it with another less-sensitive network and proceed with the design. Alternatively, the designer can choose to further confirm and understand the nature of the problem by applying other available statistical tools. One of these tools is sensitivity analysis.

Sensitivity analysis is different from yield-sensitivity histograms. Instead of varying a component over its entire process-variation range, sensitivity analysis varies the values a small amount around their nominal value. One component at a time is changed, and its effect on the entire circuit is measured. Sensitivity analysis is intended to pinpoint which elements are sensitive.

Sensitivity analysis is a good tool, but because it only makes very small changes in value and changes only one element at a time, it does not tell the whole story. It does, however, aid the designer in assessing the low-yield problem for this design.

Next, a sensitivity analysis for only the capacitors in the

example LNA design versus the  $S_{22}$  goal was performed. The output-network capacitors, C1 and C7, show high sensitivity relative to the  $S_{22}$  goal.

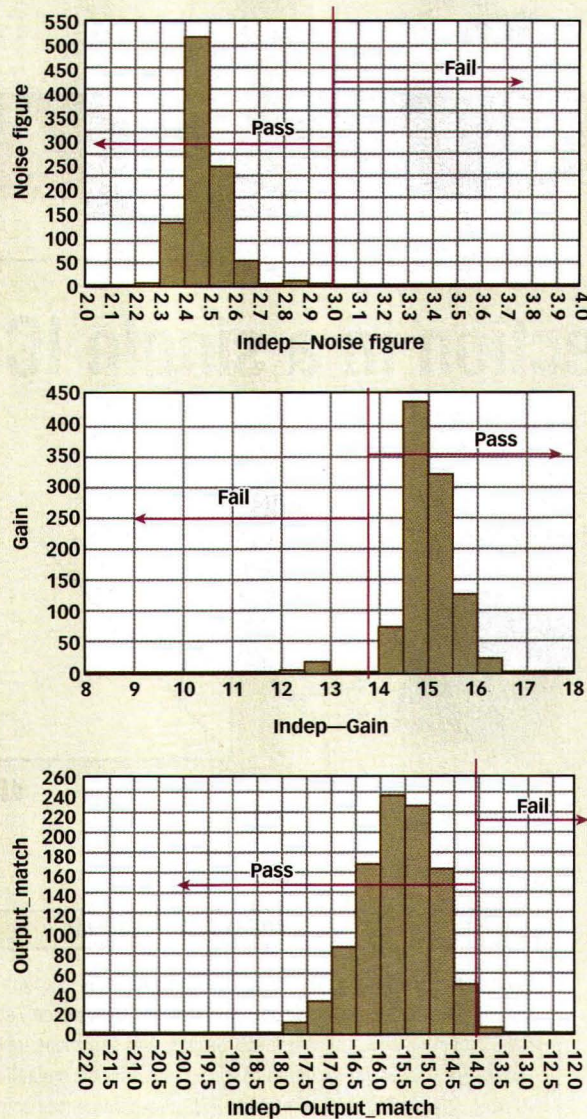
DOE is another statistical tool that can help find sensitive components or networks by building an analysis using

selected variables. DOE lets the designer set up the desired series of analyses (the experiments). There are many elements in this LNA design. To limit the size of the problem, three subsystem variables are selected, representing the input-matching network, interstage-matching network, and output-matching network. These are labeled as  $\Delta_{\text{inp}}$ ,  $\Delta_{\text{ints}}$ , and  $\Delta_{\text{out}}$ , respectively. Provided with three variables, eight experiments are run ( $2^3$ ).

Because each network consists of several variables, the designer needs to see how each network is varied within the experiments. In the input-matching network, the three variables are capacitor C1, resistor R1, and line width W1. C1 has a nominal value of 5 pF, R1 is 20  $\Omega$ , and W1 is 10  $\mu\text{m}$ . Variable  $\Delta_{\text{inp}}$  is set to the maximum variation in values, which is 5 percent. When the experiment varies the input network, the nominal values are changed by the factors  $(1 + \Delta_{\text{inp}})$  and  $(1 - \Delta_{\text{inp}})$ . The interstage- and output-matching networks are varied in the same way.

The experiments are run three times, for gain, noise figure, and output return loss,  $S_{22}$ . The DOE analysis clearly showed that the variation in the output-matching network is contributing largely to the variation in  $S_{22}$ . Similar analysis showed only small variation in the gain and the noise figure due to variation in the input- and interstage-matching networks.

The yield analysis, the yield-sensitivity histograms, the sensitivity analysis, and the DOE tool all have confirmed the need to redesign the output-matching network. The modified LNA is re-analyzed and re-optimized using the same file as before. Yield analysis was

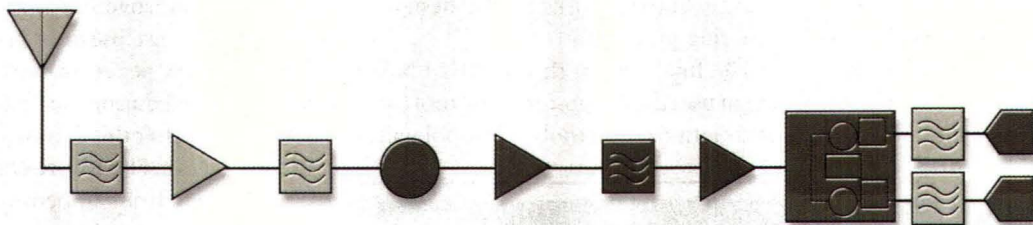


Statistical analysis of LNA performance:  
 • 5 percent Gaussian variation in lumped  
 • Line widths vary  $\pm 1/2 \mu\text{m}$   
 • Substrate height 100  $\mu\text{m} \pm 3 \mu\text{m}$   
 • Substrate Er 12.9  $\pm 5$  percent  
 • 42 FET samples

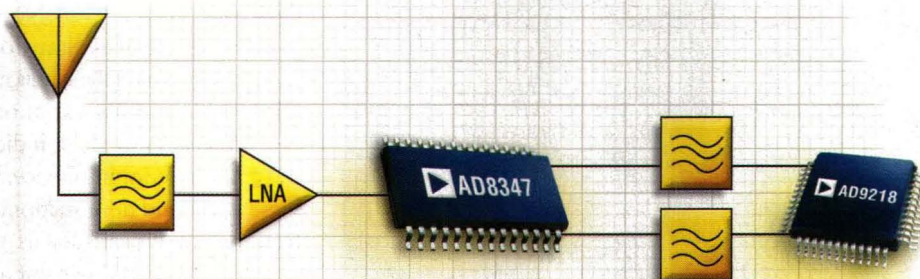
NumFail	NumPass	Yield
26.00	974.00	97.40

5. These better-than-97-percent yield results were obtained after the design-centering/yield-optimization process.

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performed on this modified LNA circuit and the result has improved to approximately 40 percent from the earlier 8.8-percent yield. The design is now less sensitive to process variation, but each component's nominal value is not yet centered for maximum yield. The pro-

cess, which moves the components' nominal values to increase the overall yield, is automated using the design-centering process.

The final step in this MMIC LNA design uses the design-centering tool (or yield-optimization tool). This tool will

adjust all the values, optimize them, and at the same time run a yield analysis. We hope to improve our 40-percent yield to something close to 100 percent. Typically, 80 to 90 percent of the improvement is obtained during the first five or ten iterations. After this automatic process, the results in **Fig. 5** were obtained, raising the yield from 40 percent up to 97.4 percent.

Although 97.4 percent is a high yield, the statistical tools can provide insight into the remaining impediments to 100-percent yield. First, examining the gain and noise-figure data from the yield analysis shows that there are two "bunches" in the gain data. One group has lower gain, while another group has higher gain. Similarly, one group has higher noise figure, while another group has lower noise figure. This suggests that there are some devices out of the 42 samples that are weak, with lower gain and, perhaps, higher noise figure. This is confirmed by viewing the yield-sensitivity histogram of the 42 devices. Seven devices such as device No. 8 and device No. 9 are simply weaker devices that do not have enough gain to meet the specifications under all possible process variations. Device No. 35 has a zero yield, indicating that it is a nonfunctioning device. Removing these weak and nonfunctioning devices from the analysis results in a yield that is very close to 100 percent and has little sensitivity to process variations.

With the final robust design, the yield-sensitivity histograms can be plotted with respect to any component in the design to see how the yield varies with component variations. The robust final design shows that the yield remains very high and flat with respect to variation in any of the components' nominal values. Yield-sensitivity histograms of the final design show consistently high yields between 95 and 100 percent across all components.

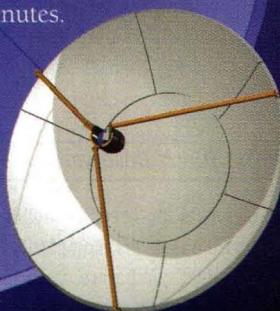
The optimization and statistical-analysis techniques in this article are demonstrated using the Advanced Design System (ADS) 2002 from Agilent EEs of EDA (Santa Clara, CA). For more information on the software tool, visit the company's website at [www.agilent.com/find/eesof](http://www.agilent.com/find/eesof). **MRF**

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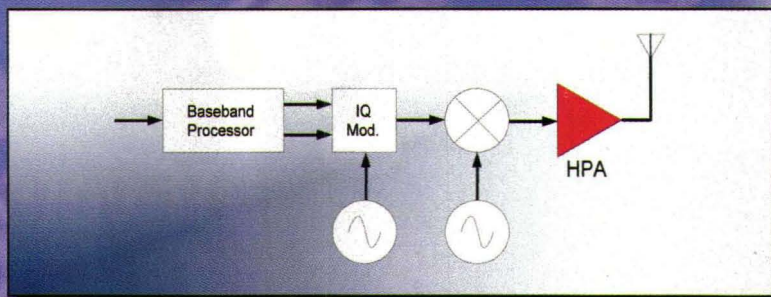
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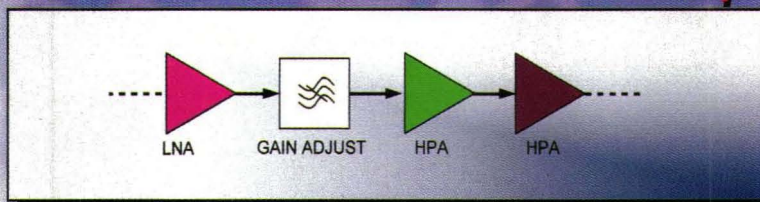
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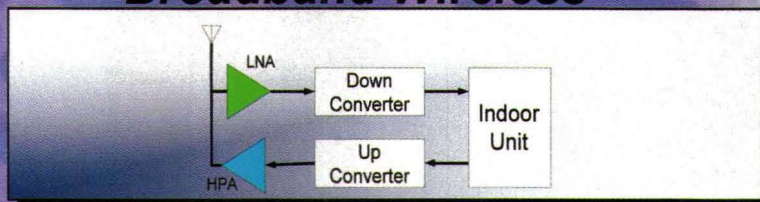
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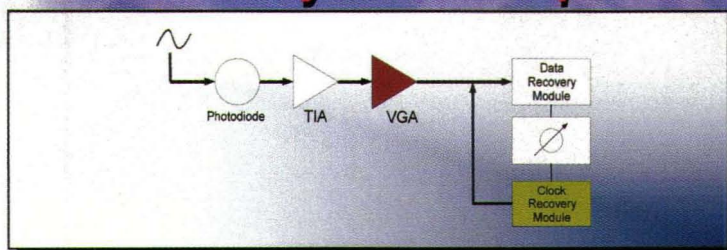
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LP1500SOT89 •  
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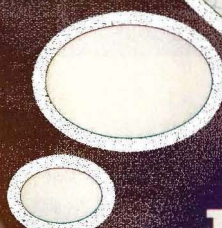
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# Setting Bias Points For Linear RF Amplifiers

The choice of biasing arrangement can determine the ultimate performance of a wireless PA in terms of output power, efficiency, linearity, and other parameters.

**C**hoosing the bias points of an RF power amplifier (PA) can also determine the level of performance ultimately possible with that PA. By comparing four PA bias approaches, designers can evaluate the trade-offs of the approaches when used for different applications. The four biasing methods are 1) using a constant reference voltage (a regulated supply sets the bias point), 2) using bias-current

feedback (where a feedback loop maintains a constant bias current), 3) having the bias current set through the output power,  $P_{out}$  (where the RF output power

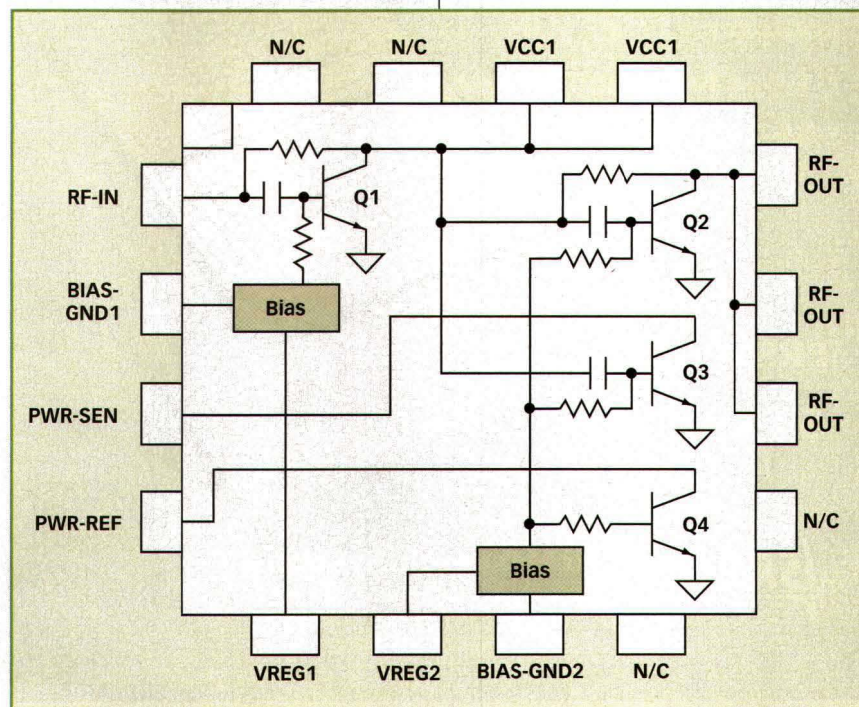
adjusts the bias current), and 4) having the bias current and voltage set through  $P_{out}$  (where the RF output power sets the PA bias current and voltage). The article this month will cover the first two of the biasing approaches. Next month will present the results of

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Senior Staff Engineer

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1. This block diagram shows the RF5117 HBT PA.



adjusting the amplifier bias and the  $V_{cc}$  supply as a function of the output power.

A model RF5117 PA from RF Micro Devices (Greensboro, NC) was used in the bias comparison. Nominally developed for use at industrial-scientific-medical (ISM) wireless-local-area-net-

work (WLAN) frequencies from 2400 to 2483 MHz, in this study the PA was tuned to the wideband-code-division-multiple-access (WCDMA) band from 1920 to 1980 MHz with measurements made in the center of the band at 1950 MHz and at room temperature. In all

cases, the supply voltage is +3.5 VDC. Minimum performance requirements included adjacent-channel power ratio (ACPR) of at least -33 dBc while providing an output power of +27 dBm.

The RF5117 has some unique features that may be useful in setting bias points. It has a patented power-sense (PWR\_SEN or PS) technology that measures the RF output power through the PWR\_SEN and power-sense-reference (PWR\_REF or PS\_REF) pins. One of the power-sense transistors has an RF coupling cap and one does not. These power-sense transistors (Q3 and Q4 in Fig. 1) are scaled versions of the output device with scaled bias resistors and a scaled coupling capacitor. Thus, the PWR\_REF collector current is pro-

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*The RF5117 has some unique features that may be useful in setting bias points. It has a patented power-sense technology that measures the output power through the power-sense and power-sense-reference pins.*

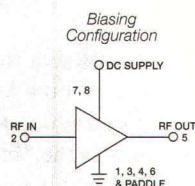
portional to the bias current, while the PWR\_SEN collector current is proportional to bias current plus the RF drive at the output stage. The RF5117 also features unique bias networks, which are essentially current mirrors with integral resistors, so the bias-current increase is quite linear with the applied regulated ( $V_{reg}$ ) voltage. This biasing feature enables the PA to maintain linearity under power backoff and reduced bias using a simple feedback circuit. A third feature of this PA comes from the new third-generation (3G) heterojunction-bipolar-transistor (HBT) process with increased beta. This reduces the current needed to set the operating bias point while increasing the amplifier gain.

The RF5117 PWR\_SEN pin will be mated with the pin on another chip labeled PS and the PWR\_REF pin will

# MNA AMPLIFIERS

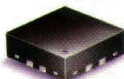
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be connected to a pin labeled PS\_REF (i.e., a reference signal). To avoid labeling confusion, the PWR\_SEN signal will be referred to as the power sense (PS) and the PWR\_REF signal will be referred to as the power-sense reference (PS\_REF).

Since linearity and efficiency are more critical issues in the WCDMA band (than at WLAN frequencies), the PA was retuned to those lower frequencies. Although the RF5117 data sheet does not specify WCDMA as an application, the PA can provide good WCDMA performance under select conditions.

In setting up PA bias conditions, various common circuit-building blocks are useful. For internal development purposes, a number of these elements

***Since linearity and efficiency are more critical issues in the WCDMA band (than at WLAN frequencies), the PA was retuned to those lower frequencies.***

(not all of which are used in this article) have been collected on a complementary-metal-oxide-semiconductor (CMOS) chip known as the "bias tool kit" (Fig. 2). The quiescent bias current for this chip is 1.25 mA at a  $V_{DD}$  of +3.5 VDC. This also includes the current through the operational amplifiers' external feedback resistors. However, the opamps must supply considerably more current than that for the PA bias. For efficiency calculations, the current consumed by the bias chip will be added to the current supplied to the PA.

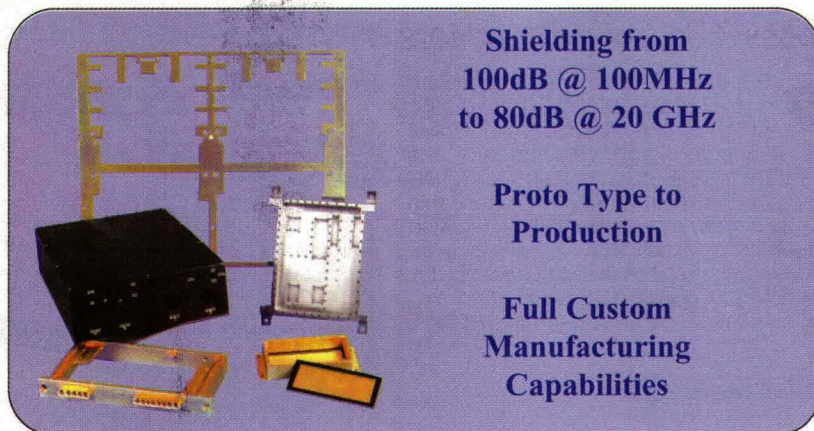
The standard PA bias approach is to supply a constant regulated reference voltage to set the quiescent bias. Normally, HBT-based PAs operate in Class AB mode at higher output power. At low power levels, the PA operates in Class A mode but undergoes self-biasing as the RF level increases. A good bias point for the RF5117 is  $V_{reg} = +2.7$

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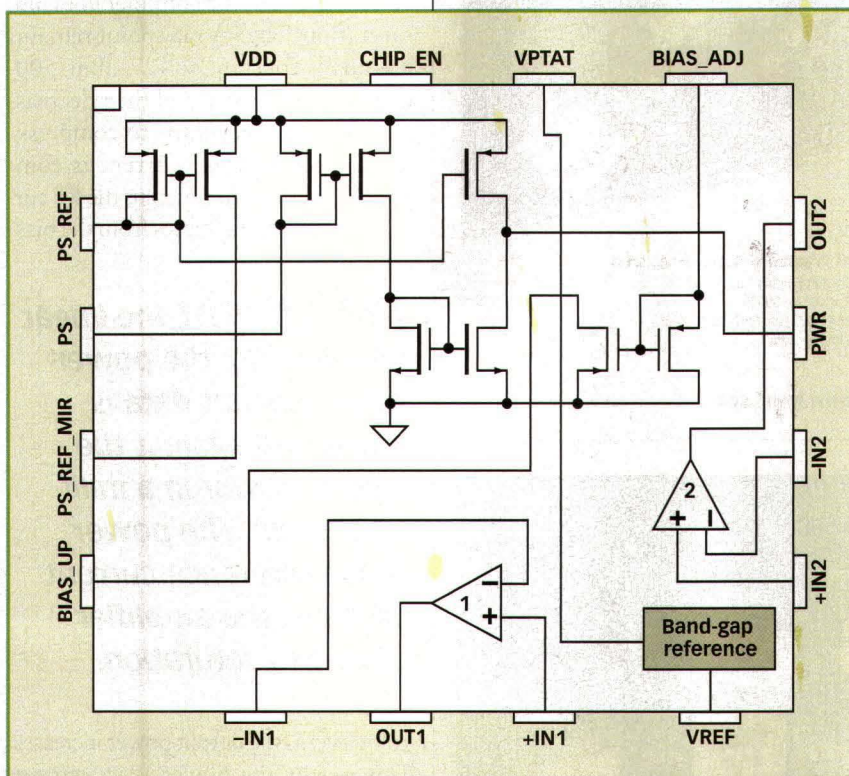
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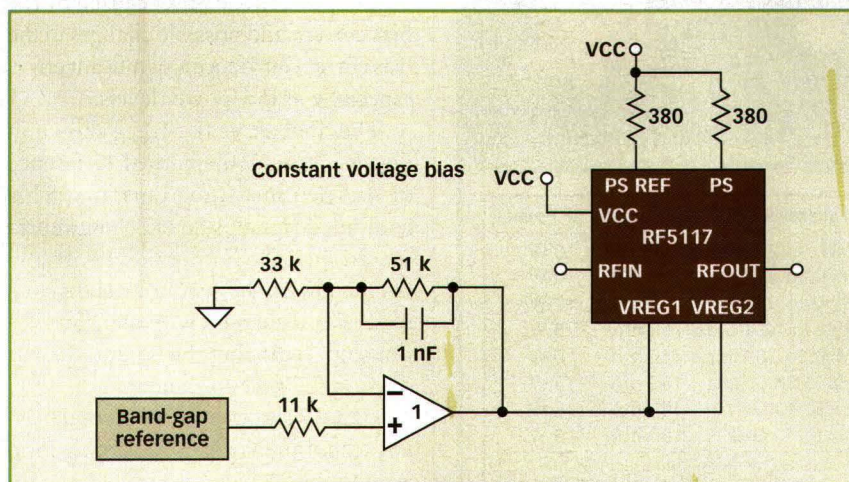
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VDC and  $V_{CC} = +3.5$  VDC. **Figure 3** shows the circuit-biasing configuration that realizes this condition. The bandgap reference provides +1.07 VDC. This is lower than the nominal silicon (Si) bandgap value due to a voltage drop in an internal buffer. The 1-nF feedback capacitor across the opamp is required for stability. The RF5117 evaluation board uses 1-nF bypass capacitors on the  $V_{reg}$  bias lines and the opamp could oscillate with the capacitive load.

Performance levels achieved with this bias approach are shown in **Figs. 4 and 5**. The gain is nominally 30 dB, while linearity drops below the -33-dBc goal at just over +27-dBm output power and approximately 33-percent efficiency. The dynamic range of the equipment limits the linearity measurement below +10 dBm. The opamp provided +2.71 VDC at a nominal current of 5.5 mA over the entire power-sweep range. The current from the bias circuitry was



2. This block diagram shows the bias tool kit for the RF5117.



3. A constant voltage is used to bias the RF5117 PA.

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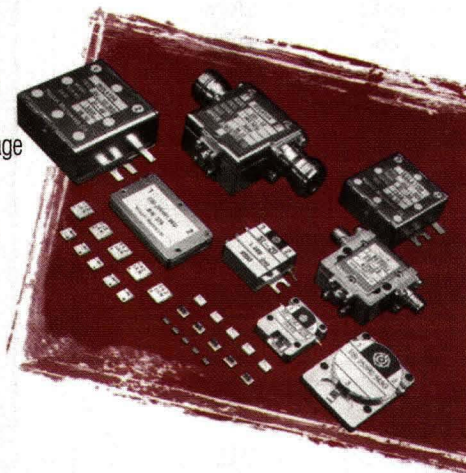
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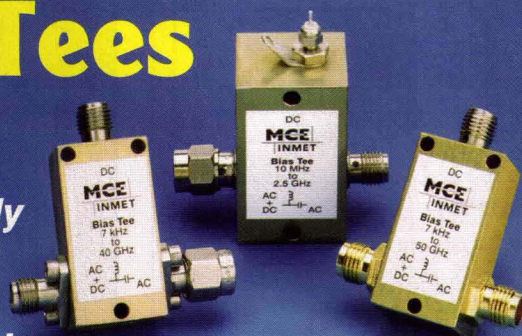
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8820SF2-18	10 MHz to 18 GHz	750 mA	5 W
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## DESIGN

included in the efficiency calculation.

The 380- $\Omega$  resistors on the PS and PS\_REF pins in Fig. 3 provide a convenient method of measuring the collector current that flows into those transistors. The voltage drop is recorded and processed into a current format. **Figure 6** shows the results of this calculation.

To highlight the linear relationship, the power-sense current data is presented against the output power in a milliwatt scale. The power-sense reference current drops as the amplifier goes into saturation. The PA bias point remains nominally constant, to +27-dBm (500-mW) output power and then decreases as the amplifier starts to compress.

The power-sense current is composed of the bias current plus the RF current. This signal increases from the bias

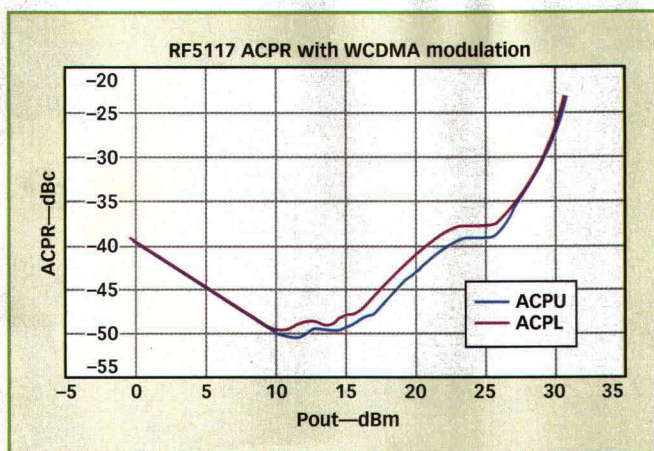
*To highlight the linear relationship, the power-sense current data is presented against the output power in a milliwatt scale. The power-sense reference current drops as the amplifier goes into saturation.*

point level as the output power increases. This is why the power-sense current alone is not an accurate measure of the output power. The offset caused by the bias current and possible changes in the bias current introduce a significant error, especially at low power levels.

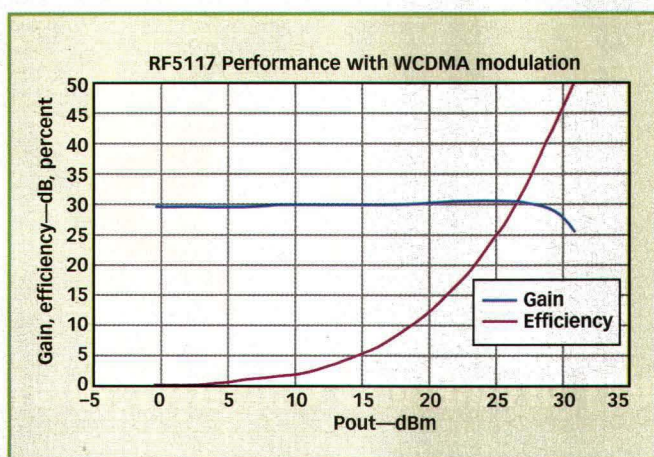
The final curve ( $I_{ps} - I_{psref}$ ) shown in Fig. 6 is the mathematical difference of the two measured currents. This computed signal is an excellent representation of the output power. At low output powers, the indicated value is close to zero and changes with a linear relationship, removing the potential error due to the bias component.

**Figure 7** shows how the second biasing technique wraps a feedback loop around the PA bias current to maintain a constant value. The PS\_REF current

5. This linearity is achieved with the RF5117 PA using a constant  $V_{reg}$  bias.



4. This performance is achieved with the RF5117 under constant  $V_{reg}$  bias.



in the RF5117 drives a p-channel current mirror, and the mirrored current is passed to the ground through the 2.2-k $\Omega$  resistor. This current comes from an open-collector HBT that sinks current proportional to the bias current. Thus, the voltage across the 2.2-k $\Omega$  resistor is proportional to the RF5117 bias current. Opamp1 (programmed with a large gain) compares the voltage across the 2.2-k $\Omega$  resistor with the bandgap voltage and adjusts the  $V_{\text{reg}}$  voltages of the PA until they match. This sets  $V_{\text{reg}}$  to approximately +2.77 VDC and provides 145-mA quiescent current in the PA.

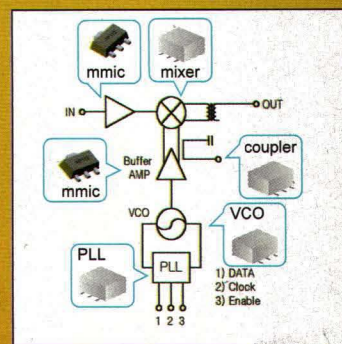
The advantage of this biasing approach appears in the form of a well-controlled bias point over temperature and a bias that is tolerant of device-processing variations. The bias current is determined by the amount of current flowing through the current mirror resistor (2.2 k $\Omega$ ). If the resistance is increased, then the feedback loop will reduce the bias point to match the voltage drop with the value of the bandgap voltage. Con-

versely, if current is “stolen” from the 2.2-k $\Omega$  resistor, the loop will increase  $V_{\text{reg}}$  to make up for the loss. Although this technique will not be presented in this article, the effect of stealing current from the 2.2-k $\Omega$  resistor is one way to adapt the amplifier bias as a function of the output power.

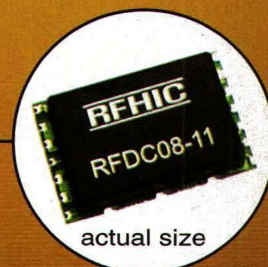
A second tap on the PS\_REF current mirror provides another copy of the bias current. This current feeds into an n-channel current mirror that is driven by a p-channel mirror, which, in turn, is driven by the PS pin of the RF5117. The power-sense current contains the bias plus RF components. There is a copy of the bias current entering the node that feeds off to opamp2 and a copy of the power-sense current (bias plus RF) leaving the node. This creates an analog subtraction function and puts the burden on opamp2 to provide the remaining current into this summing node. The current that is provided by the opamp will be proportional to the RF power. Opamp2 provides this current

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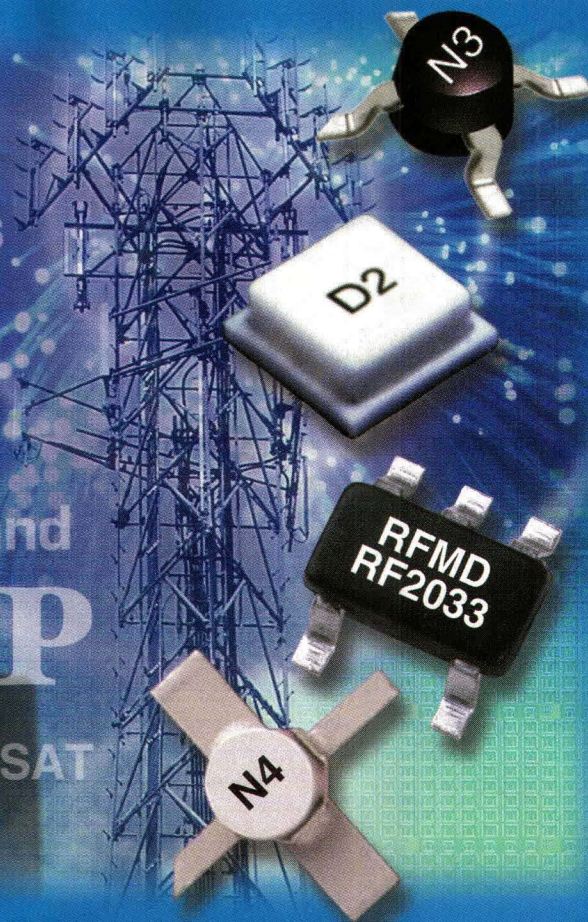
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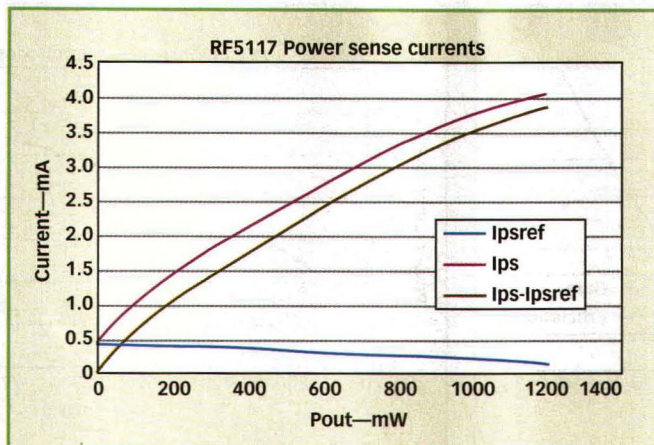
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by adjusting its output voltage until that current flows through its 15-k $\Omega$  feedback resistor. A threshold voltage of half the bandgap value is set through a voltage divider formed by the two 11-k $\Omega$  resistors. The output voltage of opamp2 will be approxi-

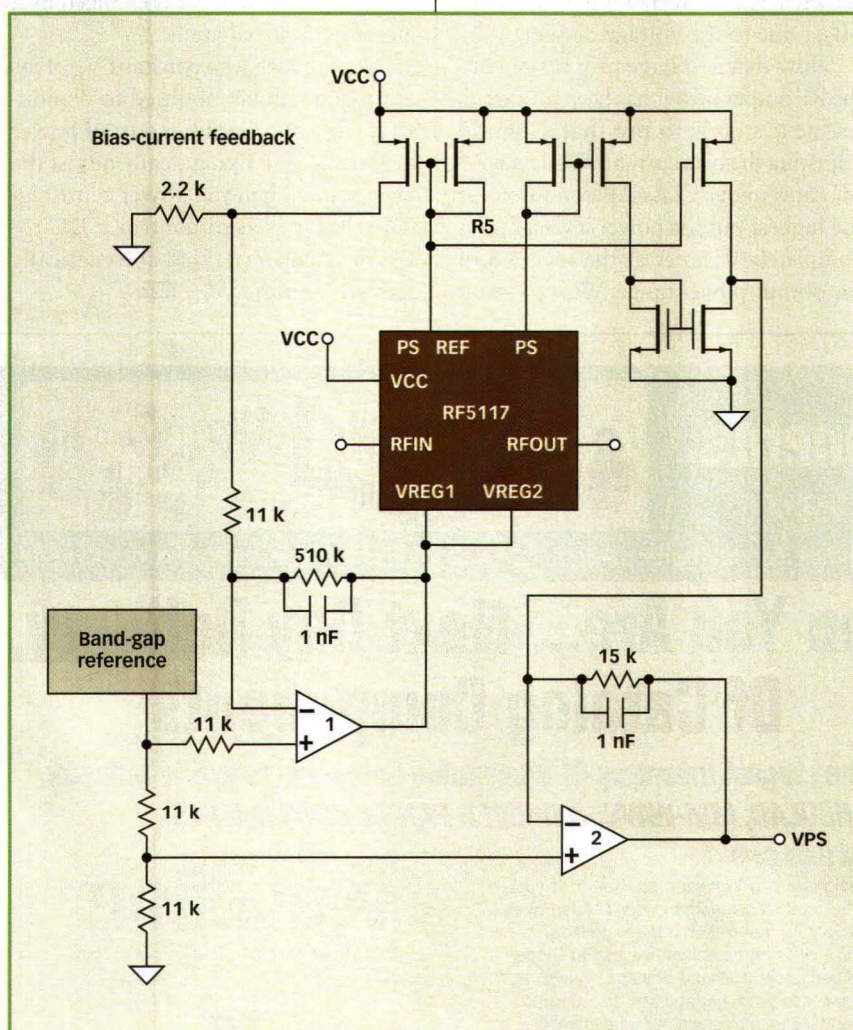


6. RF5117 power-sense currents are shown here.

mately +0.5 VDC with no RF power and it will increase with the increasing output power.

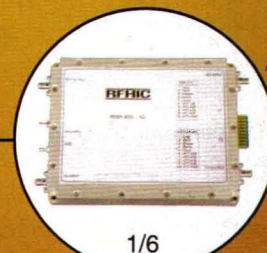
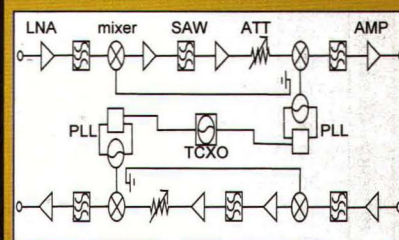
Finally, there is a 1-nF feedback capacitor on opamp2 to provide low-pass filtering. WCDMA modulation is

an approximately 3.6-dB peak-to-average (crest factor) power variation. Without the filtering, opamp2 makes a valiant attempt to track the amplitude modulation of the RF signal.



7. RF5117 bias-point set using bias-current feedback can be seen here.

## BTS & Repeater Converter Sub-System



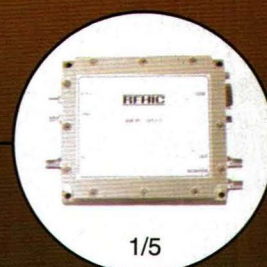
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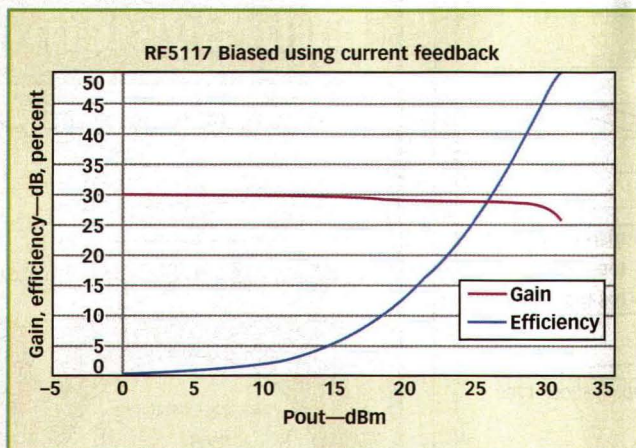
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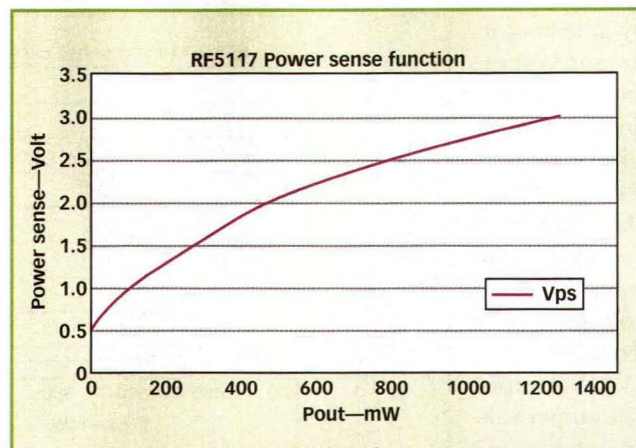
8. RF5117 performance using bias-current feedback is illustrated here.

Figure 8 shows the PA performance using this bias technique. The only difference in performance observed between this bias technique approach and the constant  $V_{reg}$  bias shown in Fig. 4, is that the gain enhancement, at approximately +25-dBm output power, has been turned into a slight gain reduction.

The ACPR performance with the bias-current-feedback approach exhibited only slight variations from the data that was measured using constant  $V_{reg}$  (Fig. 5). The new information is the performance of opamp2 that provides

the current-to-voltage conversion of the current associated with the output power. This data is shown in Fig. 9 and it is similar to the difference current shown in Fig. 6, except for the +0.5-VDC offset due to the voltage divider.

Now that a voltage proportional to the RF output power has been produced, the next step is to use that signal in adjusting the bias current. While the PA operates under Class AB conditions at the highest output-power levels, bias is completely Class A at the low end of the output-power range. With constant



9. RF5117 power-sense function is shown here.

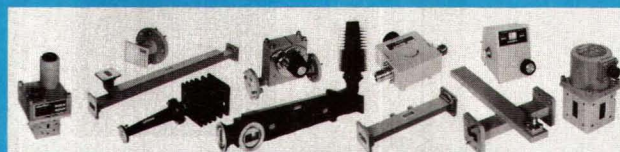
$V_{reg}$  bias, the quiescent current is 136 mA at quiescence (0 dBm out) and 456 mA at +27.2-dBm output power. The PA current is changed by a factor of 3.3, while the internal RF current is changed by a factor of approximately 22.

Next month, the constant  $V_{reg}$  bias approach will be modified to demonstrate how the amplifier output power may be used to dynamically adjust the bias point. Then the power sense signal will be used to control a DC-to-DC buck converter that automatically sets the amplifier  $V_{cc}$ . **MRF**

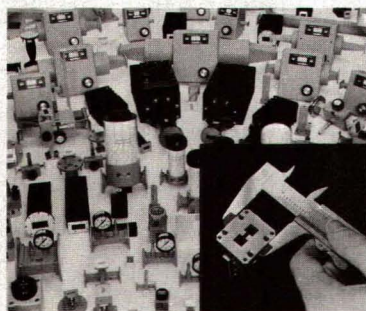
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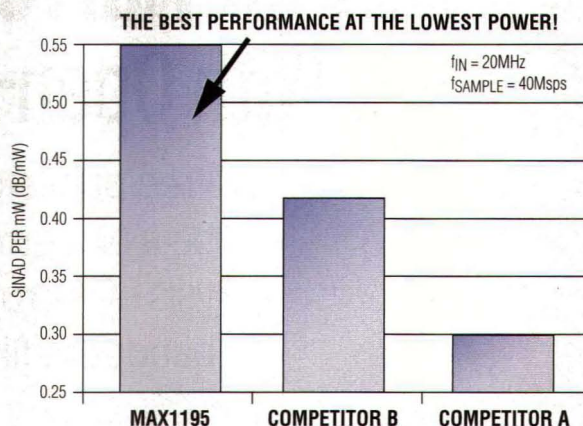
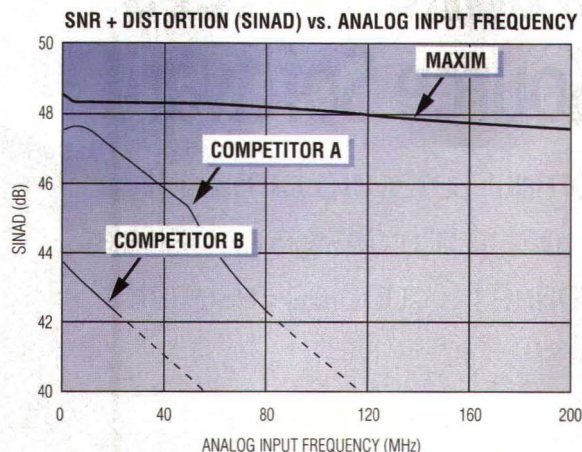
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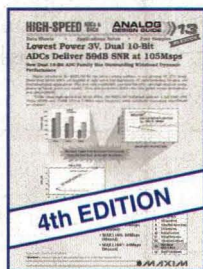
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# Design Narrowband Filters With Open-Source Software

Free public-domain software turns out to be a powerful tool in the design and analysis of narrowband LC coupled-resonator bandpass filters.

**C**oupled-resonator bandpass filters based on inductive-capacitive (LC) elements are well-suited for a wide range of applications below 1 GHz. If properly implemented, these filters can achieve stopbands as wide as several gigahertz and passbands as narrow as 1 percent. Many software programs have been developed for the design and synthesis of these filters, some with hefty price tags. But an

effective job of designing LC coupled-resonator filters can also be accomplished with open-source software.

Available programs for the design and analysis of LC coupled-resonator filters range from powerful high-end design suites such as PCFILT<sup>1</sup> down to any number of little freeware/shareware programs. Also, some full-featured circuit simulators and software suites now integrate modules for the purpose of designing filters. For no charge, engineers can also opt for open-source soft-

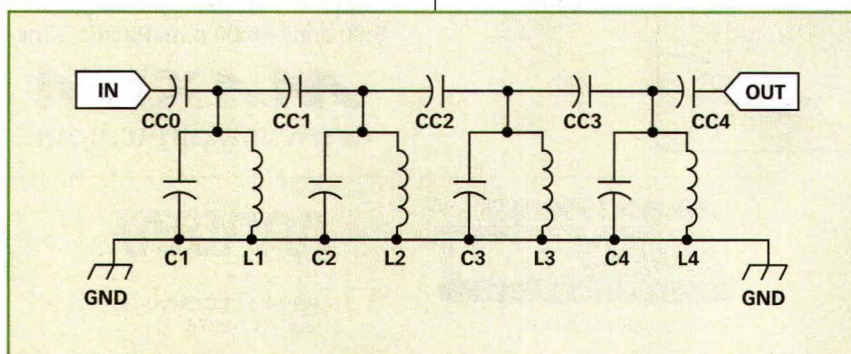
ware. The executable code and the source code are both in the public domain. As a result, the open-source soft-

ware can even be tailored (with the help of a programmer or two) to fit a specific application. To demonstrate the capabilities of open-source software, it will be used to design a practical LC coupled-resonator bandpass filter.

The first step in designing the filter is to choose its topology. The popular "top C" coupled filter topology is useful for filters having bandwidths of less than about 20 percent (Fig. 1).<sup>1</sup> This filter class supports the use of convenient L and C

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1. This schematic diagram shows a four-pole, top-C coupled-filter topology that is well-suited for narrowband filter designs.

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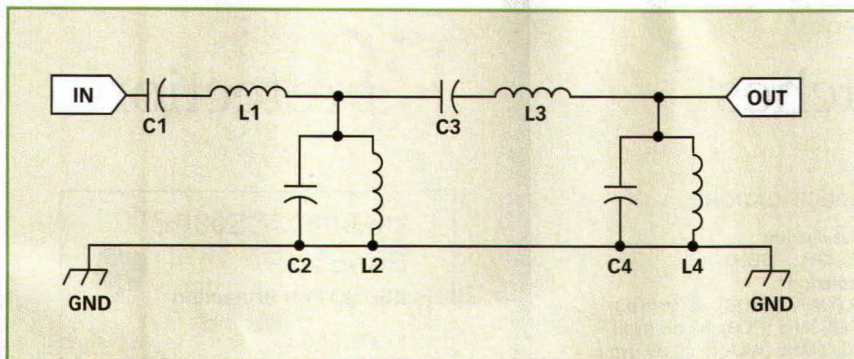


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2. This schematic diagram shows a four-pole, direct-scaled filter topology that is well-suited for wideband filters.

values. Since the coupling capacitors add a degree of freedom in the design, the filter can be scaled so that at least some of its components have standard values, and all of the inductors have nearly the same value, making the final design easy to produce and low in cost. The stopband of this topology is steeper below, rather than above the passband, since the reactance of the coupling capacitors is a decreasing function of frequency.

The direct-scaled filter topology (Fig. 2) provides a more-symmetric stopband response<sup>2</sup> and can have wider bandwidth. This topology is useful for wideband filters, but component values tend to be impractical for narrowband designs (for which the top-C coupled-filter topology is a better choice).

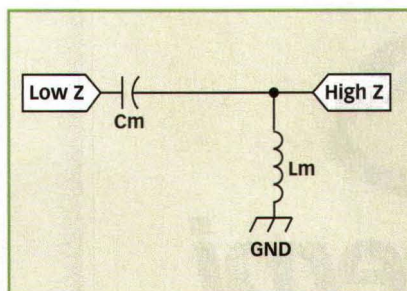
A top-C coupled filter consists of a series of coupled resonators known as "tank circuits," which store RF energy. Each tank circuit consists of one coil and one capacitor such as L1 and C1 in Fig. 1. Each tank has a resonant frequency ( $f_0$ ) equal to the filter's geometric center frequency,  $f_0 = (f_1 \times f_2)^{0.5}$ , where  $f_1$  is the lowest frequency in the passband and  $f_2$  is the highest frequency in the passband.

Each tank circuit has an impedance value which is equal to the impedance of the coil or the capacitor at  $f_0$ . Theoretically, any impedance value can be chosen. The tanks are not required to have the same impedance value, so different values can be used. The values of the coupling capacitors can be adjusted to accommodate whichever impedance value is convenient. The input and output coupling structures in Fig. 1 assume

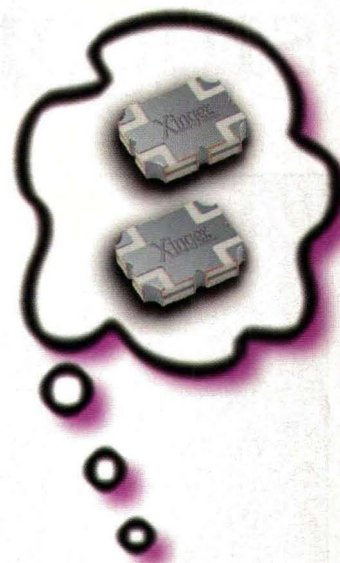
that the tank impedances are higher than the terminating impedances, which is usually the case. If the tank impedances are lower than the terminating impedances, a different coupling structure must be used.

A filter can be designed by first choosing the number of sections (such as four) and the response type (Chebychev). Lowpass prototype (g) values for this filter can be calculated or found from a table of values. Convenient values for the four capacitors (C1 through C4) must then be chosen, selecting capacitor impedances that are higher than the terminating impedances. Then, inductors are chosen to resonate with capacitors C1 through C4. Interstage coupling capacitors CC1 through CC3 are then chosen to provide the correct coefficient of coupling between sections.<sup>3</sup>

What results from these selections of components is a bandpass filter, but with input and output impedances that are higher than desired. To match the filter to its terminations, impedance transformers are needed at the input and output ports. The L section of Fig. 3 is an



3. This L-matching circuit can be used to match a filter's input and output ports to the terminating impedances.



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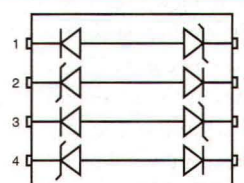


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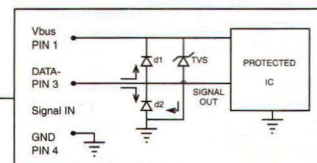


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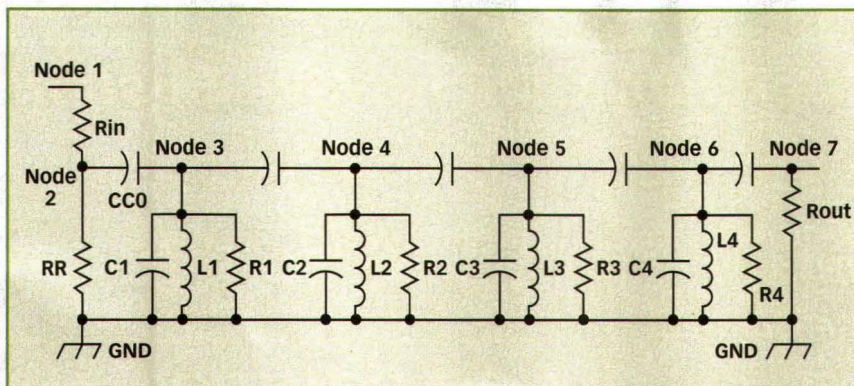
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4. This schematic filter diagram was developed for modeling performance with the SPICE simulator.

appropriate impedance transformation. Its  $L_m$  inductor and  $C_m$  capacitor values are chosen to step down from the filter impedance to the terminating impedance. Since matching inductor  $L_m$  is connected in parallel with the filter's first (or last) tank inductor, the two inductors may be replaced by a single coil with inductance equal to the parallel combination of  $L_m$  and the tank inductance. Capacitors  $CC0$  and  $CC4$  of Fig. 1 have a value of  $C_m$ . A filter can have different input and output impedances, in which case the matching networks will have different component values at the input and output ports.

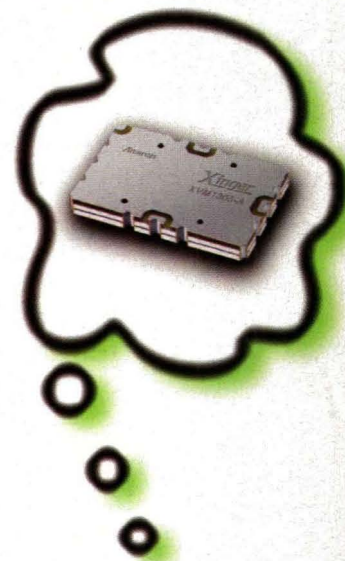
After reducing the inductances of the first and last coils, the final design is close, but at least two different inductor values are still needed. By changing the impedance of the first and last tanks, it is possible to use approximately the same inductance value for all of the coils. Using this approach, the inclusion of variable inductors can save costs. In addition to making all of the coils the same value, it is possible to choose the tank impedances so that the tank capacitors are standard values, making the filter lower in cost and easier to produce.

With this filter-design approach, it is helpful to have a filter-synthesis program that allows a user to choose the impedance values of the various tanks arbitrarily, and to modify those values until an optimum combination is found. The open-source program LUMPEDT.EXE handles the task of choosing component values for a top-

C coupled bandpass filter and allows tank impedances to be chosen arbitrarily. A tank circuit's impedance is not chosen directly, but as the value of the tank's parallel capacitor. The program then chooses the appropriate inductance and coupling capacitance to accompany a selected tank-parallel capacitor. Since the code is open source, engineers capable of writing a few lines in C++ can customize the program by adding features such as different topologies, different netlist formats, etc. Borland has even made a suitable C++ compiler that is available for free.<sup>4</sup>

## System Requirements

The system requirements for running LUMPEDT.EXE are trivial. Any DOS or Windows personal computer (PC) with at least 640 kb of random-access memory (RAM) will suffice. The software generates an output file containing the filter's  $g$  values and component values, as well as an estimate of the filter's midband loss. The software also generates a Simulation Program with Integrated Circuit Emphasis (SPICE) netlist file which includes an AC voltage source to drive the filter, an input resistor with value equal to the filter's input resistance, a high-value dummy resistor to facilitate SPICE DC analysis, inductors and capacitors for the actual filter, resistors in parallel with the inductors, to simulate inductor loss, and a load resistor. For a filter with  $N$  number of tank circuits, the SPICE model has  $N + 3$



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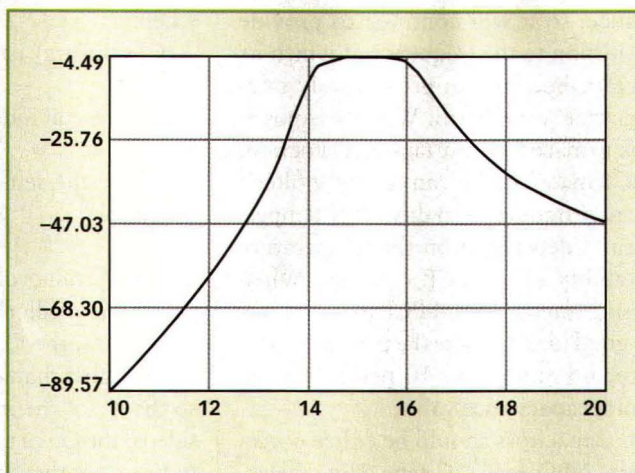
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nodes. Note that LUMPEDT.EXE and SPICE are available free from the author's web-site at [www.qfilter.com](http://www.qfilter.com).

To demonstrate an example with LUMPEDT.EXE, the software will be used to design a four-pole band-pass filter with pass-band of 14 to 16 MHz. Input and output impedances will be 50  $\Omega$ , pass-band ripple will be 0.5 dB, and the unloaded quality factor ( $Q_u$ ) of the coils will be 45. All of these design requirements are entered into LUMPEDT.EXE at the appropriate prompts after the program is started. Then a value of  $100 \times 10^{-12}$  (100 pF) is entered when the program prompts the operator for the desired value of the tank capacitors. Once the program displays an initial filter design, a user is prompted to change the nominal value of any of the tank capacitors. For example, the values of C1 and C4 could be made smaller so that the values of L1 and L4 were nearly the same as the values of the other coils. Copies of the output file and netlist for this example are included with the program on [www.qfilter.com](http://www.qfilter.com).

## SPICE Simulation

Once component values have been chosen for the example filter, SPICE can be run to model the filter's response. Referring to Fig. 4, note that input and output resistors,  $R_{in}$  and  $R_{out}$ , respectively, have been added to the circuit to simulate the source and load impedances, while resistors R1 through R4 have been added to simulate the loss of the tank circuits. Resistor RR has been added so that the SPICE simulator can bypass the DC analysis step.<sup>5</sup> Resistor RR has a very large value and has a negligible effect on the AC analysis.



5. Using SPICE, the response of the coupled-resonator filter was plotted from 10 to 20 MHz.

The simulation results (Fig. 5) show that the stopband slope is steeper below the passband than above it, and the midband insertion loss is close to the predicted value of 4.38 dB. The loss of the coils causes the passband to be somewhat rounded, with more loss at the band edges than at the center. Also due to the losses, there is no discernible passband ripple, even though the filter was designed for a ripple of 0.5 dB.

If the predicted stopband rejection is sufficient, the next step is to build the filter. If the model shows that the rejection is insufficient, then the number of resonators must be increased, or the bandwidth of the passband must be decreased and the design process repeated with new parameters.

Such characteristics as filter center frequency, bandwidth, and desired insertion loss will determine the importance of different construction issues. If parasitic reactances and stray coupling are minimized by intelligent layout and careful component selection, the constructed filter should perform according to the SPICE model.

The most-common problem in filter construction is stray coupling from input to output. If a 10-pole filter is laid out on a circuit board in such a way that the input coil and output coil are next to one another, the magnetic-field coupling between these two coils may be on the order of 20 to 30 dB, making it impossible, for example, to achieve 80-



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dB rejection without additional measures [such the use of shielding, and machined aluminum (Al) housings]. Stray capacitive coupling can have the same negative effect on performance. Any coupling that allows out-of-band energy to travel uncontrolled throughout the filter must be eliminated. This sort of stray coupling is sometimes known as "blow-by."

One way to avoid blow-by is to individually shield each filter section in a metal can. In the case of high-performance very-high-frequency (VHF) or ultrahigh-frequency (UHF) filters, this is often necessary. If unshielded coils are used, magnetic coupling between coils can be minimized by making the axes of adjacent coils perpendicular to one another. In some cases, it may be adequate to simply lay out the filter in a straight line across a circuit board, relying on the distance between input and output to prevent stray coupling. At lower frequencies where shielded variable inductors are used, this is often adequate. In cases where the filter has only a few sections and relatively little stopband attenuation is required, blow-by may not be an issue.

Lead or trace inductance in series with the tank capacitor is another common problem in filter design. If this stray inductance is too high, it will prevent the capacitor from having low impedance at high frequency, and will limit high-frequency stopband rejection. In general, one side of the tank capacitor should be connected directly to ground, and the other side should be connected to the two coupling capacitors. This may force a designer to put a little trace inductance in series with the tank inductor.

If the filter's stopband must extend to several gigahertz, the series inductance of the chip capacitor itself may be a problem. In this case, it is a good idea to place a small patch of copper (Cu) on top of the filter's printed-circuit board (PCB), forming a low-inductance "printed" capacitor in parallel with the chip capacitor. The sum of their values will be the tank capacitance. The printed capacitor will have negligible induc-

tance, so it will continue to provide rejection to the frequency at which its width becomes approximately one-quarter wavelength. While it is possible to make the entire tank capacitor from PCB material, this can cause the filter's center frequency to drift over temperature, depending on the temperature stability of the PCB material. When using standard FR-4 PCB material, it is a good idea to make the printed capacitor no more than 10 percent of the total capacitance value.

Capacitors should be either porcelain, NPO, or COG type. High dielectric-constant dielectric capacitors such

***Lead or trace inductance in series with the tank capacitor is another common problem in filter design. If this stray inductance is too high, it will prevent the capacitor from having low impedance at high frequency.***

as X7R or Z5U should never be used, even though they are available in low-capacitance values. These capacitors can change value by up to 80 percent as a function of temperature, which would cause the filter's center frequency to drift wildly.

As physical capacitors have stray inductance, physical inductors have stray capacitance. This stray capacitance appears in parallel with the inductor. While it does not really cause much trouble, the inductor's parallel capacitance should still be subtracted from the value of the physical tank capacitor so that the physical capacitor and the stray capacitance add up to the desired value.

Inductors are generally specified in terms of their unloaded Q,  $Q_u$ , and their self-resonant frequency (SRF). The stray parallel capacitance ( $C_s$ ) is equal to  $C_s = 1/[L(2\pi\text{SRF})^2]$ ,

where:

$C_s$  = the stray parallel capacitance (in farads),

$L$  = the coil inductance (in henrys), and

SRF = the self-resonant frequency (in hertz).

The  $Q_u$  values of the tank circuits will determine a filter's bandpass loss. In most cases, the  $Q_u$  of the capacitor is much higher than that of the inductor, so the  $Q_u$  of the inductor can be considered the  $Q_u$  of the entire tank circuit. In the event that the capacitor has significant loss, the tank  $Q_u$  will be equal to  $Q_u = (Q_c^2 + Q_l^2)^{0.5}$

where:

$Q_l$  = the unloaded Q of the tank inductor and

$Q_c$  = the unloaded Q of the tank capacitor.

Generally, one of the tank components will be made variable so that the tank circuits can be tuned to resonate at exactly the correct frequency. If the filter's bandwidth is to be accurate, the inductor should be made variable and the tank capacitor should be fixed. This is because the ratio of the tank capacitor to the coupling capacitor determines the filter's coefficients of coupling from stage to stage.

The LUMPEDT.EXE filter synthesis program enables engineers to design filters that are low in cost and easy to manufacture. The LUMPEDT.EXE filter-synthesis program and the SPICE simulator are free of charge from the author's website at [www.qfilter.com](http://www.qfilter.com). The filter synthesis program's source code can be modified and recompiled using an early version of Turbo C++, which is also available free. **MRF**

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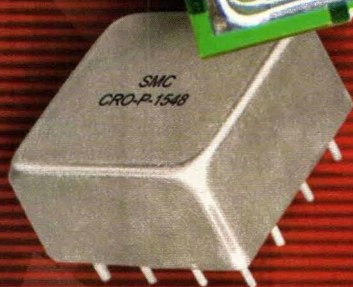
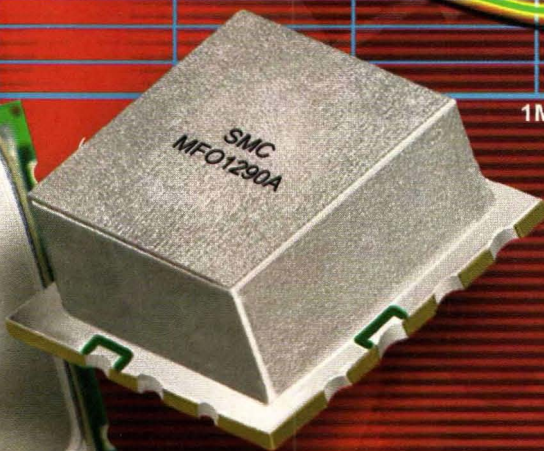
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13dB	DBTC-13-5-75	5-1000	1.0	19
		1000-1500	1.4	17
16dB	DBTC-16-5-75	5-1000	1.0	21
		1000-1500	1.3	19
17dB	DBTC-17-5	50-1000	0.9	20
		1000-1500	1.0	20
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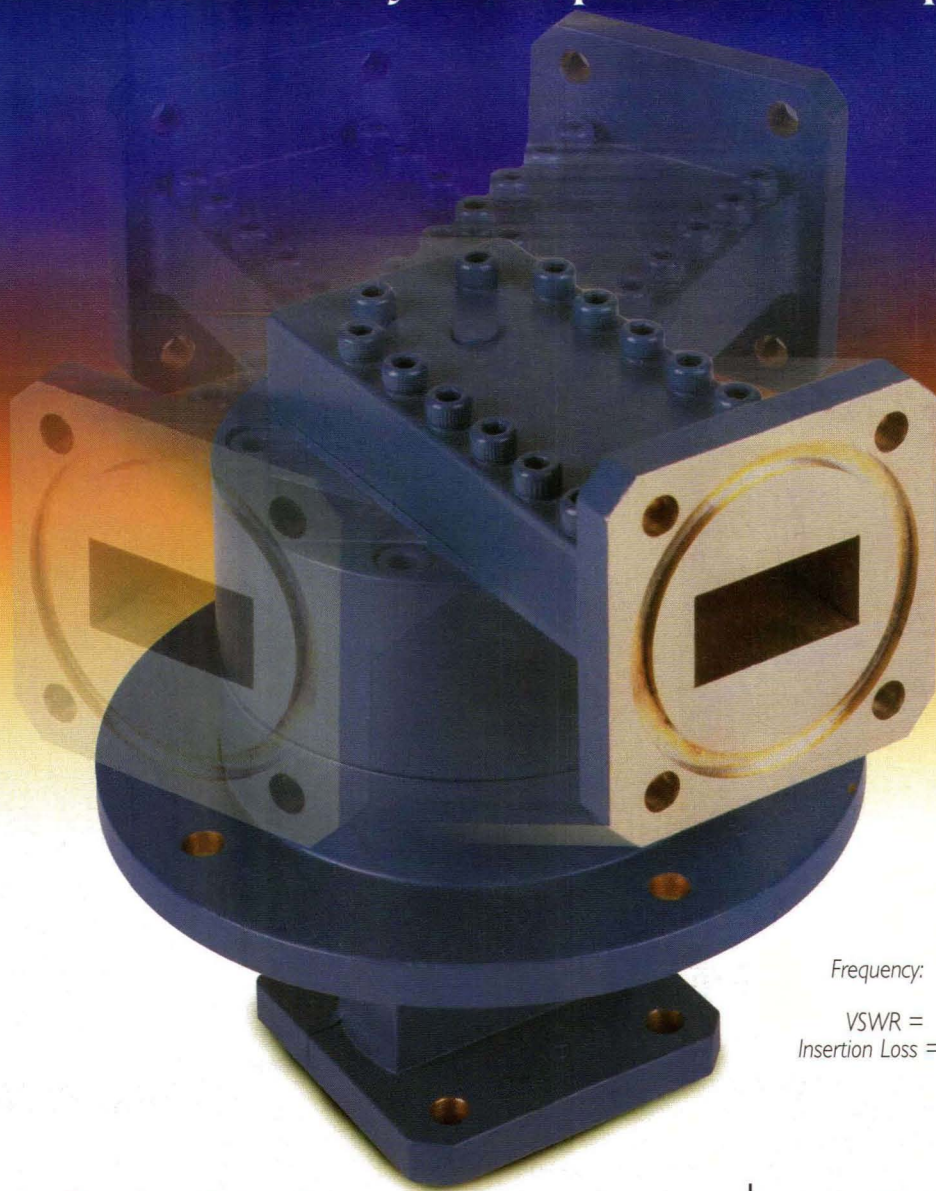
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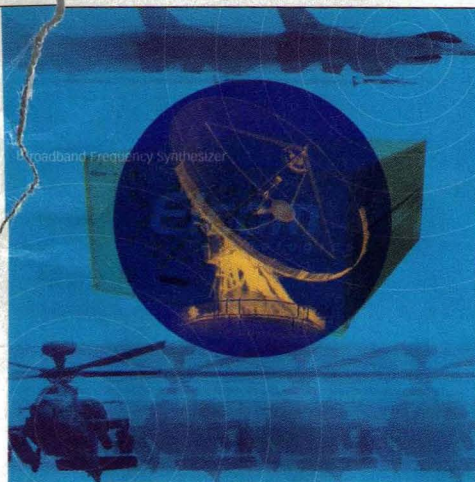
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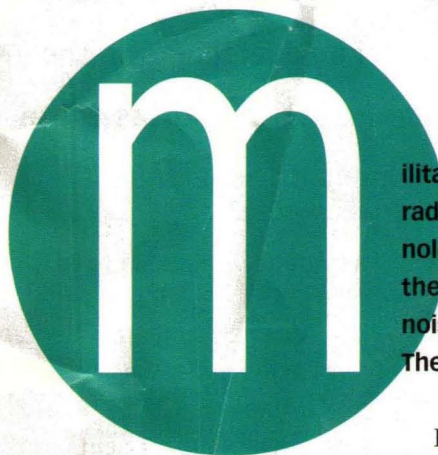


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# Synthesizers Offer Submicrosecond Switching

A series of broadband frequency synthesizers provides very low phase noise with submicrosecond switching time for military applications.



Military systems require low-noise synthesizers with fast switching for radar, electronic-warfare (EW), and surveillance applications. Elcom Technologies' (Rockleigh, NJ) UFS series of modular synthesizers addresses these applications with submicrosecond switching speed and phase noise that represents up to a 30-dB improvement over existing products. The UFS series also covers a wide bandwidth, ranging from 0.01 to 40 GHz.

Broadband synthesizers are divided into two groups (techniques)—yttrium iron garnet (YIG) and direct analog. The YIG group is based on YIG oscillators that are phase locked to a low-phase-noise reference. This technique provides a very-low-phase-noise floor ( $-160$  dBc) across the 0.01-to-40-GHz frequency range, switching speed limited by the inductance of the YIG tuning coil. As a result, the switching speed is limited to approximately 1 ms. Also, due to the division ratios inside the phase-locked loop (PLL), the phase noise at 10 kHz from the carrier is higher than the noise floor ( $-117$  dBc at 10 kHz offset from the 10-GHz carrier compared to  $-160$  dBc offset 10 MHz from the carrier).

The second group is based on direct-analog techniques (arithmetic operations on main and auxiliary frequencies) combined with digital direct synthesis (DDS) for fine-step resolution. Although this method is more complex, it enables fast switching speeds (0.2 ms) with low phase noise. The switching speed is controlled

**PETER STAVENICK**  
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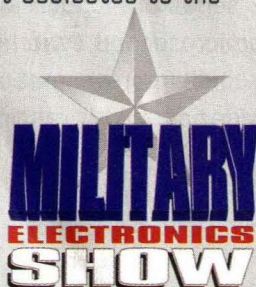
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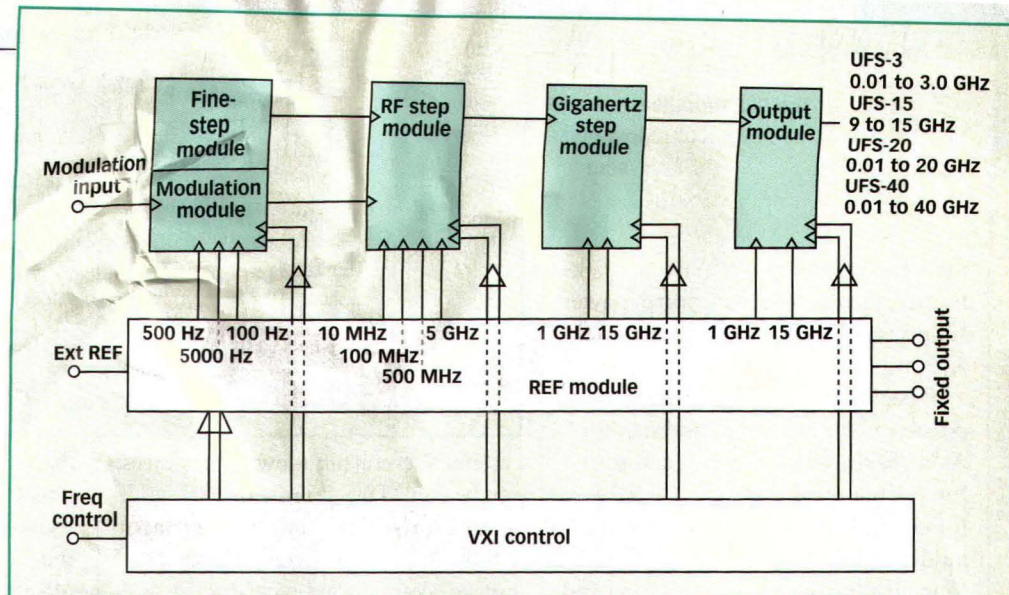
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by the propagation delay through bandpass filters and switches inside the synthesizer. Phase noise is limited by internal-source phase noise. In the UFS series of synthesizers, a proprietary phase-locked direct resonator oscillator (DRO) features a noise floor of -165 dBc at 500 kHz offset from a 10-GHz signal.

The series of synthesizers provides 100-MHz modulation with a switch-speed range of 150 to 200 ns. Harmonics range from -50 to -60 dBc with frequency resolution of less than 0.1 Hz for the UFS-3, UFS-20, and UFS-40. For the UFS-15, the switching speed is 150 ns. The frequency modulation is 100-MHz peak-to-peak deviation for all synthesizers, while phase noise is -95 dBc offset 100 Hz from the carrier for the UFS-3 and UFS-15.



1. The six basic modules of a synthesizer are the VXI interface and control, REF module, fine step and modulation, and RF step, as well as Gigahertz step and output module.

For the UFS-20 and UFS-40, phase noise is -90 dBc offset 100 Hz from the carrier and -84 dBc offset 100 Hz from the carrier, respectively. With the UFS-3, phase noise is -155 dBc offset 100 kHz from the carrier. For the UFS-15, it is -152 dBc offset 100 kHz from

the carrier, the UFS-20's phase noise is -150 dBc offset 100 kHz from the carrier, and the UFS-40's phase noise at 100 kHz is -144 dBc offset from the carrier (see table).

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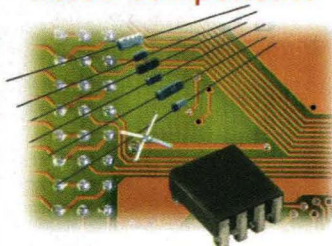
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## 2. The REF module combines several ultra-low noise sources.

the UFS series employs existing mainframes, such as VXI, for control power supply and packaging. Custom packages are optional.

Basic modules are used for several possible frequency ranges and step sizes. As a result, units can be customized for various requirements. The UFS-3, for example, requires a simple output module while the UFS-15 requires only four slots (no need for modulation and output module).

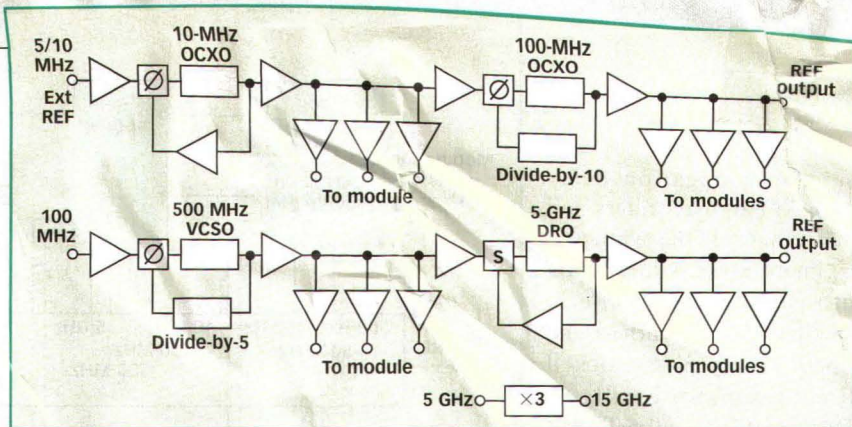
The overall block diagram of the UFS series synthesizer in Fig. 1 shows the basic six modules of the synthesizer. They consist of VXI interface and control, reference (REF) module, fine-step and modulation module, RF-step module, gigahertz-step module, and output-step module.

In Fig. 2, the REF module, which

combines several ultra-low noise sources, can be seen. They consist of a 10-MHz oven-controlled crystal oscillator (OCXO), 500-MHz voltage-controlled surface-acoustic-wave oscillator (VCSO), and 5-GHz voltage-controlled dielectric resonator oscillator (VCDRO). Every source has optimal phase noise at differential offset. If all of the phase noises are translated to 5 GHz, then 10 MHz has the best phase noise for the offset ranging from 1 to 100 Hz. The 100-MHz OCXO offers the best phase noise from 100 Hz to 2 kHz. The 500-MHz VCSO source excels to 10 kHz and

the 5-GHz DRO provides the best noise floor. To optimize performance, the sources are phase locked in series with the loop bandwidth for phase-noise offset purposes.

With the wide-modulation module, the modulation signal is applied to fixed-frequency voltage-controlled-oscillator (VCO)-based PLL. The arrangement keeps modulation constant over the full synthesizer bandwidth. A two-point modulation method supports wide frequency-modulation (FM) bandwidths from DC to 200 MHz, even with a loop bandwidth of 100 kHz. This reduces



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## Towards A Global 3G System: Advanced Mobile Communications In Europe, Vol. 1

**RAMJEE PRASAD**

DESCRIBING AND ANALYZING the results of the Mobile-Domain ACTS projects, and including implementation case studies, *Towards A Global 3G System: Advanced Mobile Communications In Europe, Vol. 1*, edited by Ramjee Prasad, covers terrestrial and satellite UMTS air interfaces, terrestrial and satellite broadband wireless, wireless access, terrestrial and satellite networks, enabling technologies, multimedia, and broadcasting.

Chapter 1 focuses on the evolution toward 3G mobile and fixed wireless telecommunications systems. UMTS, mobile satellite systems, wireless broadband communications, high-data-rate demands, WLANs, and ATM-based wireless mobile broadband multimedia systems are covered.

Chapter 2 examines the ACTS Mobile Domain. The ACTS Program, the mobile domain, the scope of the domain, organizations and activities, and ACTS/IST programs in the scope of the future mobile communications are explored.

Chapter 3 provides an investigation into terrestrial air interfaces. Terrestrial UMTS, Future-Radio Wideband-Access Schemes, mobile services for HSTs, UMTS security architecture, and wireless broadband systems are discussed. Wireless ATM network demonstrator, wireless broadband CPN for professional and residential multimedia applications, ATM wireless-access communication system, System for Advanced Mobile Broadband applications, and ACTS Broadband Communications Joint Trial and Demonstration are explained. Wireless access systems, two-layer architecture for fully wireless interactive broadband service access, cellular-radio access to Interactive Television and Broadband Services, agent-based mobile access to information services, and mobile multimedia access using intelligent agents are covered.

Chapter 4 features satellite air interfaces. Satellite UMTS, novel satellite mobile applications, Integrated S-UMTS Real Environment Demonstrator, Intertrial Testbed for Mobile Applications of Satellite Communications, satellite broadband communications, Satellite EHF Communications for mobile multimedia services, and Convergence of Internet-ATM Satellite are presented. A summary of trials is included.

Chapter 5 offers information on networks. Radio Access Independent Broadband on Wireless, the RAISIN Demonstrator, Software Tools for Optimization of Resources in Mobile Systems, Advanced Security for Personal Technologies are covered. Enhancements on ATM-Based B-ISDN, FRANS satellite networks, complementary satellite systems and terrestrial networks, and Service Platform for Other ACTS Trials and Application are also presented. (2001, 319 pp., hardcover, ISBN: 1-58053-138-5, \$110.00.) Artech House, 685 Canton St., Norwood, MA 02062; (800) 225-9977, (781) 769-9750, FAX: (781) 769-6334, Internet: [www.artech-house.com](http://www.artech-house.com).

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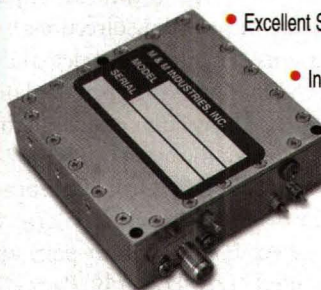
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## Design an LNA using a low-noise PHEMT device

THE ATF-35143 IS a member of a family of high-dynamic-range, low-noise, pseudomorphic-high-electron-mobility-transistor (PHEMT) devices that are designed for use in low-cost commercial applications in the very-high-frequency (VHF) range through 6 GHz. Application note 1271 from Agilent Technologies (Santa Clara, CA), entitled "Low Noise Amplifier for 3.5 GHz using the Agilent ATF-35143 Low Noise PHEMT," offers specifications, a component-parts list, schematics, graphs, and a performance summary for a low-noise amplifier (LNA) that is has been designed using the ATF-35143, as well as providing information on biasing options, source grounding, source-inductance amounts, and circuit stability.

The ATF-35143 LNA targets the 3.4-to-3.8-GHz wireless-local-loop (WLL), wireless-broadband-access, and digital microwave radio markets. Parameters at 3.5 GHz include a gain of 13.4 dB, a 0.9-dB noise figure, and a supply current of 30 mA. Output third-order intercept point (IP3) is 27.0 dBm, while input IP3 is 13.6 dBm. Input return loss is 24.0 dB, while output return loss is 12.3 dB. Output P1dB

compression is +14.5 dBm.

The LNA uses a highpass impedance-matching network comprised of a series capacitor and a shunt inductor for the noise match. The unit's 400- $\mu$ m gate width tolerates large amounts of source inductance, enabling the designer to take advantage of self biasing, which only requires a single positive power supply. The ATF-35143's scattering (S) and noise parameters are tested in a fixture that features plated and through holes through a 0.025-in. (0.064-cm) thick printed-circuit board (PCB). The transmission lines that connect each source lead to its corresponding plated through hole is simulated as a microstripline (MLIN).

Linear and nonlinear analyses yields simulations for gain versus frequency, noise figure versus frequency, and input and output return loss versus frequency. This note is available as a free download from the company's website.

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*Global Positioning System (GPS) receivers (Rxs) are popular time-saving devices that are useful for providing directions in all types of situations.*

## Circuit integrates GPS chip, Rx, and charge pump

GLOBAL POSITIONING SYSTEM (GPS) receivers (Rxs) are popular time-saving devices that are useful for providing directions in all types of situations. The increased demand for embedded GPS functionality in personal digital assistants (PDAs) and cellular phones in the last five years has yielded the model UPB1007K GPS Rx integrated circuit (IC) from California Eastern Laboratories (CEL; Santa Clara, CA) and NEC (Tokyo, Japan). A four-page application note entitled "Low Power IC Packs GPS Receivers" by Olivier Bernard, Eric Bausback, and Benoit Krummenacker of CEL breaks the IC down to its main parts (charge pump, GPS chip, Rx) and provides specifications for each.

Using the ultra-high-speed UHS0 25-GHz transition-frequency bipolar process, the IC features improved noise figures, which enables the integration of a phase-detector-driven charge pump and a low-noise amplifier (LNA) on-chip with the remaining GPS Rx circuitry. The 2.5-mA LNA features a noise figure of less than 3 dB and associated gain of 15 dB. The GPS chip

also features an integrated mixer, a voltage-controlled oscillator (VCO), and a crystal oscillator, which results in less frequency pulling on the phase-locked loop (PLL) and the phase detectors.

The IC's superheterodyne dual-downconversion Rx architecture is designed to process 1575.42-MHz signals from the antenna through either a discrete LNA or the onboard LNA. The signals are downconverted to a first intermediate frequency (IF) of 61.38 MHz by mixing with the 1636.8-MHz signals from the onboard local oscillator (LO). The LO is used to create a second set of signals at 65.472 MHz for the second downconversion process, resulting in a second IF of 4.092 MHz typical. The IC operates from -40 to +85°C. This application note is available as a free download from the company's website.

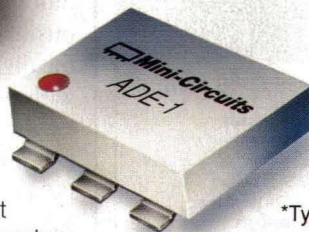
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L-I Isolation (dB)	40	37
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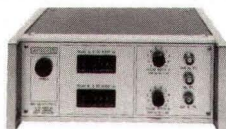
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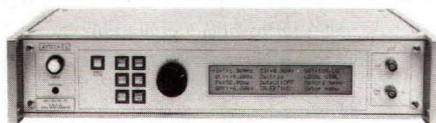


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## UFS synthesizer data

SPECIFICATION	UNITS	UFS-3	UFS-15	UFS-20	UFS-40
Frequency range	GHz	0.01 to 3.0	9 to 15	0.01 to 20	0.01 to 40
Frequency resolution	Hz	<0.1 Hz	5 MHz	<0.1 Hz	<0.1 Hz
Switching speed	ns	200	150	200	200
Spurious	dBc	-80	-80	-70	-64
Harmonics	dBc	-50	-60	-50	-50
Output power	dBm	10 $\pm$ 2	10 $\pm$ 2	10 $\pm$ 2	10 min.
Phase noise					
Offset 100 Hz		-95	-95	-90	-84
1 kHz		-112	-110	-108	-102
10 kHz		-132	-129	-125	-119
100 kHz		-155	-152	-150	-144
1 MHz		-160	-157	-154	-148
Modulation					
FM	Peak-to-peak deviation	100 MHz	100 MHz	100 MHz	100 MHz
QAM		TBD	TBD	TBD	TBD
Size	C size VXI slots	5 single	4 single	6 single	6 single

the noise floor of the modulation PLL. For continuous wave (CW), amplitude modulation (AM), and quadrature amplitude modulation (QAM), the FM PLL is disabled. The modulation signals are directed to an ultra-low phase-noise CW source, deriving from the 500-MHz VCSO. AM, phase, and QAM [using in-phase/quadrature (I/Q)] modulation can be set according to customer requirements (DC to 200 MHz).

The fine-step module has several options. A DDS section provides steps of less than 250 kHz. DDS spurious are reduced by the mixer and divide modules. Coherent operation to the external REF is maintained by using proprietary technology.

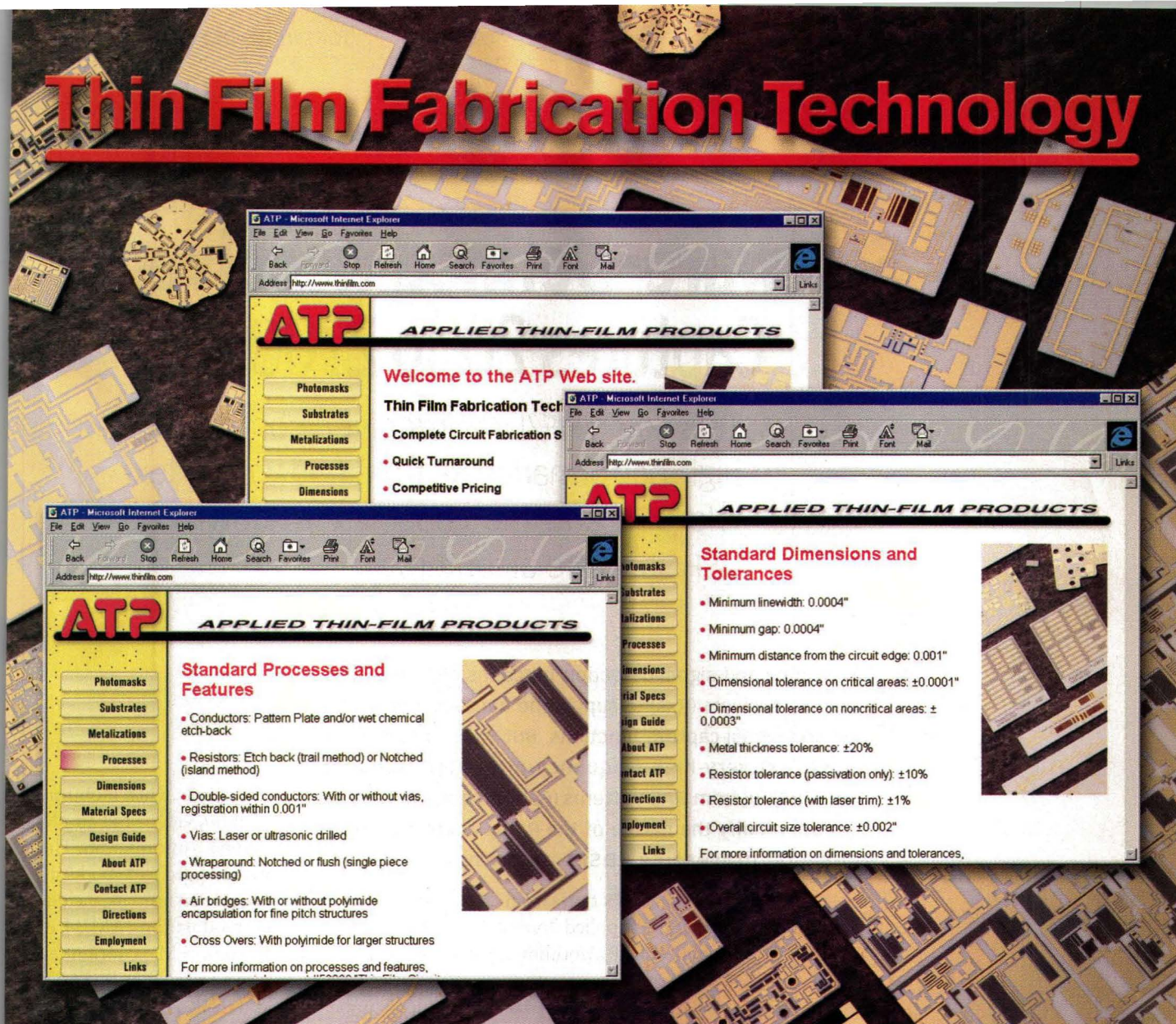
The RF step uses mix and divide techniques. The basic block could repeat itself until the bandwidth and step resolution are being met. Also, every block improves the spurious from the previous block by a factor of  $20\log N$  due to the divide-by-N stage. This supports the use of DDS stages with relatively high spurious in the front blocks. The most hardware-efficient N was found to be 4, reducing the number of required frequencies to 4. Also single-pole, four-throw (SP4T) switches and divide-by-4 prescalers are common and easy-to-find components. The gigahertz-step module employs a base 12 synthesizer stage for high-speed switching.

The output-step converts the basic 10-to-20-GHz octave to the required range. For the full 40-GHz band, the module uses a doubler with a switchable filter bank to screen unwanted subharmonics. A switchable lowpass filter cleans the harmonics after mixing in the low-frequency band. Some models use a simpler output section. UFS-3 only uses a mixing and switchable lowpass filter. For UFS-15, the output directly derives from the gigahertz step module, eliminating the section.

The synthesizers can be customized to many frequency ranges, including 2 to 20 GHz, 8 to 12 GHz, and 12 to 18 GHz. Step sizes include less than 0.1 Hz, 250 kHz, 5 MHz, and 50 MHz, while modulation includes FM, AM, QAM, and PM. Elcom Technologies, 11 Volvo Dr., Rockleigh, NJ 07647; (201) 767-8030 ext. 223, FAX: (201) 767-6266, e-mail: [uri@elcom-tech.com](mailto:uri@elcom-tech.com), Internet: [www.elcom-tech.com](http://www.elcom-tech.com).

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# Software-Defined Receiver Captures 20 To 2700 MHz

This VXI VHF/UHF receiver combines a high-performance RF front end with a flexible DSP and the capability to download DSP software algorithms.

**S**urveillance and signal-detection functions once required a bank of receivers (Rxs) to supply the necessary demodulation and signal-capture functions. But with the model WJ-8629A VXI very-high-frequency/ultra-high-frequency (VHF/UHF) Rx from BAE Systems (Gaithersburg, MD), operators can modify the nature of the Rx by downloading digital-signal-processing (DSP) algorithms. The high-

for example, when monitoring audio, video, and amplitude/phase information. The Rx is equipped to demodulate

performance Rx tunes from 20 to 2700 MHz and is supplied "preloaded" with a variety of DSP algorithms for standard surveillance Rx operations.

The WJ-8629A software-definable Rx is a single-slot C-size VMEbus VXI module that combines a high-performance mixer-based RF front end with a general-purpose DSP running at 1 GFLOPS. The solidly constructed receiver features surface-mount components mounted on multiplayer printed-circuit boards (PCBs). A milled aluminum (Al) chassis provides isolation between multiple PCBs.

The WJ-8629A's front end features three stages of mixer-based downconversion, with the third intermediate frequency (IF) [a 1.3-MHz bandwidth centered at 2 MHz] sampled by a 14-b analog-to-digital converter (ADC). Further digital downconversion is performed before a 1-GFLOPS C6701 DSP from Texas Instruments (Dallas, TX) processes the sampled data. Analog reconstruction circuits and digital-to-analog converters (DACs) are used to return data (where required) to the analog realm,

a variety of modulation formats, including amplitude modulation (AM), frequency modulation (FM), continuous wave (CW), lower sideband (LSB), upper sideband (USB), and frequency-shift-keying (FSK) modulation. In addition, memory is provided for up to four user-downloadable custom demodulation algorithms.

The Rx achieves a typical third-order intercept point (IP3) of +10 dBm and a typical noise figure (with its built-in preamplifier) of 12 dB. With the preamplifier on, the input second-order intercept point (IP2) is typically +55 dBm. The input port is protected against signal levels up to +30 dBm (1 W). Adjacent-channel rejection is typically 60 dB, image rejection is 90 dB, and IF rejection is 90 dB. The single-sideband (SSB) phase noise is better than -97 dBc/Hz offset 20 kHz from the carrier, and typically -115 dBc/Hz offset 100 kHz from the carrier.

The Rx offers a total of 22 IF (3-dB) filter bandwidths, ranging from 200 Hz to 1.23 MHz. Typical filter shape fac-

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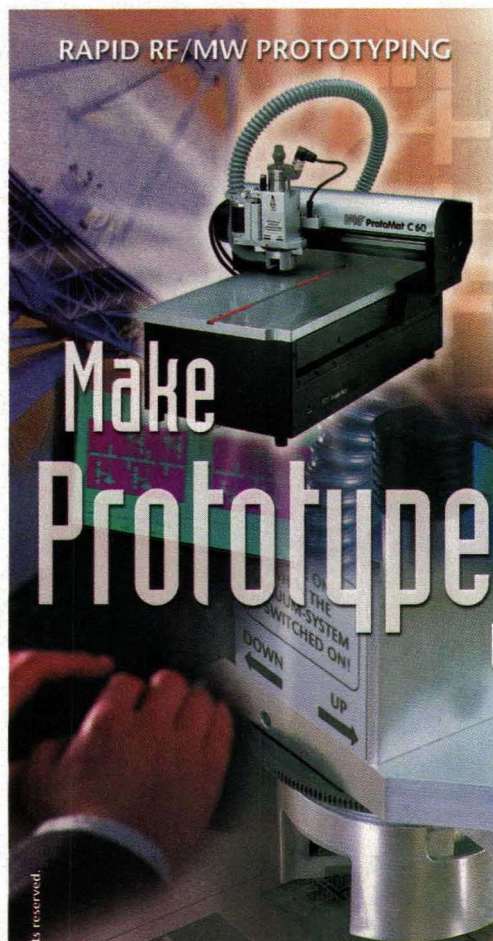
tors are better than 1.35:1. For example, the Rx offers a 100-kHz IF filter with up to 100-dB out-of-band rejection and only 0.01-dB ripple. The filter shape factor is 1.25:1. The digital filter operates at a data rate of 125 kSamples/s. In contrast, a 1-MHz IF filter provides up

to 90-dB out-of-band rejection of unwanted signals with only 0.1-dB ripple and a shape factor of less than 1.35:1. This filter operates at a rate of 2 kSamples/s. When using the 100-kHz Rx bandwidth with AM/FM signals, the sensitivity from 20 to 1200 MHz is -93 dBm.

When using the 1-MHz IF filter with AM/FM signals, the Rx sensitivity is -83 dBm. The Rx also provides up to five memory slots for users to download custom filter algorithms when the Rx is equipped with option 8629A/SDR. Users can also create new DSP filter algorithms by using the company's Sunrise DSP Software Developer's Kit.

The WJ-8629A features three operating modes: manual mode for fixed-frequency use, sweep mode for contiguous coverage of up to 10 start/stop frequency sectors, and step mode for tuning to preprogrammed discrete frequencies. The Rx is interactive in all three modes and alerts the host computer of signal activity. While in either the sweep or step mode, the Rx logs individual signals in the coverage area and

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***The receiver includes a shared-memory first-in, first-out (FIFO) circuit connected to the VXI interface. The shared-memory FIFO can be used in continuous or snapshot mode.***

reports only changes in signal presence to the VXI controller, reducing processing overhead time for the controller in multiple-Rx applications. The sweep time for memorized frequencies is typically 100 channels per second, while the start-to-stop-frequency sweep time is typically 3 ms per point. Tuning resolution is 10 Hz at the demodulated output port and 1 kHz at the analog IF output ports.

The Rx includes a shared-memory first-in, first-out (FIFO) circuit connected to the VXI interface. The shared-memory FIFO can be used in continuous (capturing the most-recent continuous data) or snapshot mode (triggered by the VXI controller). The Rx controller can access the shared-memory FIFO by either 16- or 32-b VXI bus paths. The

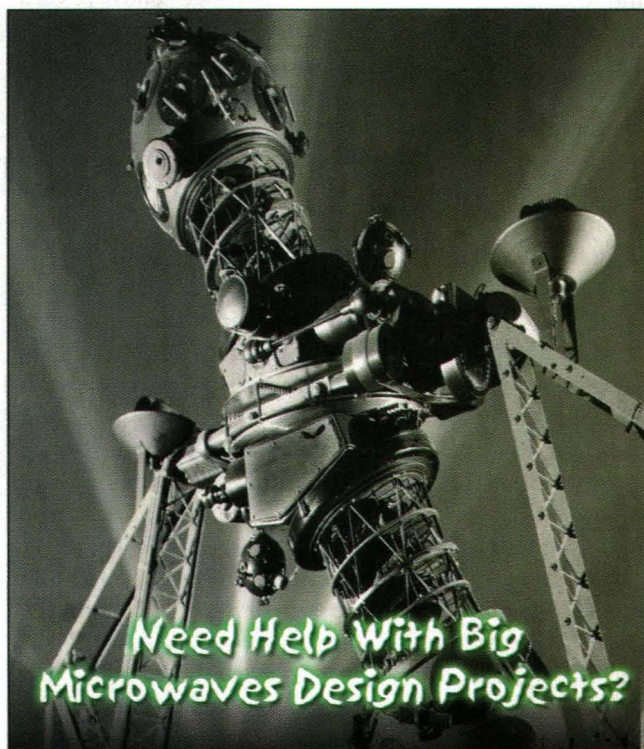
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## PRODUCT technology

Rx can load the FIFO with unprocessed ADC samples, filters in-phase/quadrature (I/Q) data, video data, 8- or 16-kSamples/s filtered audio data, or filtered magnitude/phase information. The Rx provides unprocessed 14-b ADC samples at a rate of 8 MSamples/s. The digital-signal data rate of the I/Q, magnitude/phase, and video data is based on the selected IF bandwidth. The WJ-8629A provides a variety of output information, including audio, video, magnitude/phase, and I/Q information.

The WJ-8629A VXI Rx offers a wideband output port with minimum 3-dB bandwidth of 12.5 MHz centered at 21.4 MHz. The Rx is equipped with a stable 10-MHz frequency reference with  $\pm 1$  PPM accuracy, but will also work with an external 10-MHz reference should enhanced accuracy be required. Internal switching allows the WJ-8629A to route samples of its three local oscillators (LOs) to another Rx so that two Rxs can be linked to form a two-channel phase-coherent system. Synchronization signals are provided through the VXI bus. BAE Systems, 700 Quince Orchard Rd., Gaithersburg, MD 20878-1194; (301) 948-7550, FAX: (301) 921-9479, Internet: [www.signalsurveillance.com](http://www.signalsurveillance.com).

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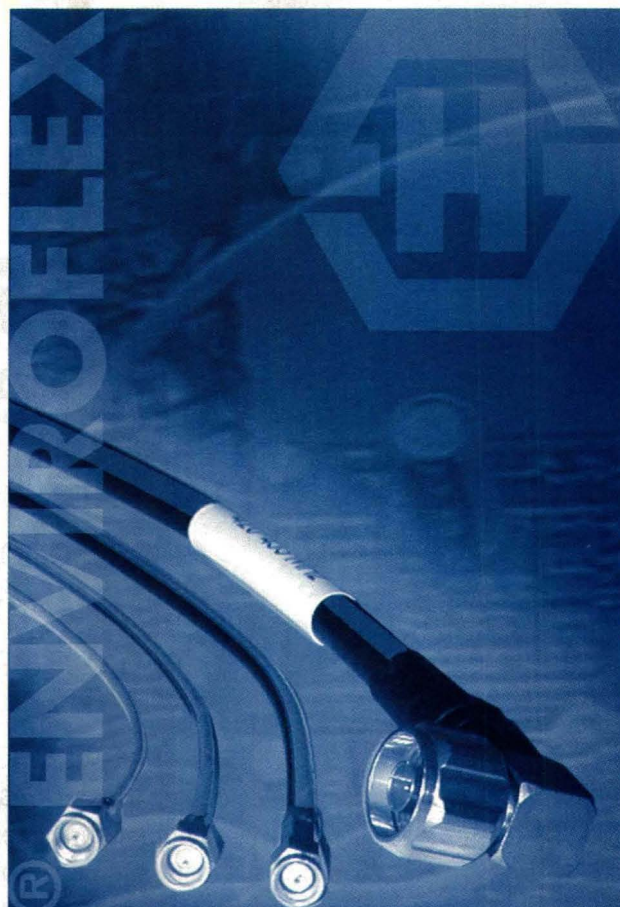


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# Single CMOS Chip Receives GPS Signals

This low-power, all-CMOS IC is a complete high-performance, low-power RF front-end downconverter supplied in a compact 48-pin TQFP package.

**G**lobal Positioning System (GPS) receivers (Rx) have become more commonplace in recent years, now often sold as options in many car models or integrated into personal digital assistants (PDAs). To help the spread of GPS Rx integration, Valence Semiconductor (Irvine, CA) has developed an all-complementary-metal-oxide-semiconductor (CMOS) single-chip Rx front-end solution, the model VS7001. Housed

stage voltage-controlled oscillator (VCO). The on-board PLL synthesizer circuitry has been designed for use with

in a 48-pin thin-quad-flat-pack (TQFP) package, the Rx integrated circuit (IC) features all the on-chip amplification, filtering, and signal generation required to convert 1.57542-GHz L1 GPS signals to intermediate-frequency (IF) signals at 1.023 MHz.

The Rx IC is fabricated with a 0.35- $\mu$ m CMOS process that supports low-power operation. The VS7001 is designed to run on supply voltages from +2.3 to +3.6 VDC, and consumes only 30-mW power at +2.3 VDC. One of the benefits of this low power consumption is long run times in battery-powered applications, such as handheld GPS Rx for outdoor use. The VS7001 is designed for operating temperatures from -40 to +85°C.

In creating a GPS Rx with the VS7001, few additional components are required. The IC operates without need of an external IF surface-acoustic-wave (SAW) filter, requiring only a front-end 1.57542-GHz bandpass filter at the input of the device. An external phase-locked-loop (PLL) loop filter is also required to lock the frequency of the on-board first-

an external crystal resonator with typical frequency of 18.414 MHz and minimum of 18.410 MHz. With a 70-kHz PLL loop bandwidth, the synthesizer limits spurious noise to -70 dBc.

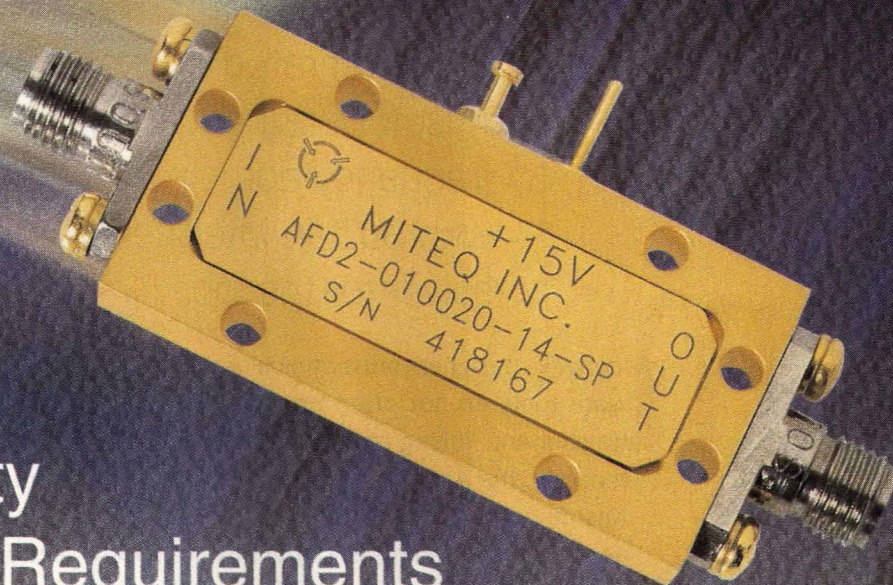
The VS7001 contributes up to 120-dB conversion gain to received signals, achieving a signal-to-noise ratio (SNR) of typically 27 dB when measured at comparator-output pin 28 for a 100-Hz resolution bandwidth and an RF input of -120 dBm. When evaluated with test tones at +20 and +39 MHz from the GPS carrier, the third-order intercept point (IP3) is typically -12 dBm (and no worse than -15 dBm). An external low-noise amplifier (LNA) should be used with the VS7001 to lower the system noise figure.

Reference designs and evaluation boards for the VS7001 are currently available. Valence Semiconductor, 41 Discovery, Irvine, CA 92618; (949) 655-4100, FAX: (949) 428-4133, e-mail: support@valencesemi.com, Internet: www.valencesemi.com.

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# Moderate & Octave Band Amplifiers



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MODEL NUMBER	FREQ. (GHz)	GAIN (dB, Min.)	GAIN FLATNESS (±dB, Max.)	NOISE FIGURE (dB, Max.)	IN/OUT VSWR	POWER OUT (dBm, Min.)	CURRENT (mA, Typ.)
AFD2-010020-14-SP	1-2	20	1.50	1.4	2.0:1	+10	100
AFD3-010020-14-SP	1-2	34	1.25	1.4	2.0:1	+10	120
AFD3-022023-12-SP	2.2-2.3	30	0.50	1.2	1.5:1	+10	100
AFD3-023027-12-SP	2.3-2.7	30	0.50	1.2	1.5:1	+10	100
AFD3-027031-12-SP	2.7-3.1	30	0.50	1.2	1.5:1	+10	100
AFD3-031035-12-SP	3.1-3.5	30	0.50	1.2	1.5:1	+10	100
AFD3-037042-12-SP	3.7-4.2	30	0.50	1.2	1.5:1	+10	100
AFD3-040080-35-SP	4-8	24	1.25	3.5	2.0:1	+10	150
AFD3-020080-40-SP	2-8	23	1.50	4.0	2.0:1	+10	150
AFD3-040120-55-SP	4-12	18	1.50	5.5	2.0:1	+10	150
AFD3-080120-50-SP	8-12	18	1.25	5.0	2.0:1	+10	150
AFD1-010020-23P-SP	1-2	11	1.00	4.0	2.0:1	+23	275
AFD2-010020-23P-SP	1-2	25	1.50	3.5	2.0:1	+23	400
AFD3-020027-23P-SP	2.0-2.7	22	1.25	4.5	2.0:1	+23	350
AFD3-027031-23P-SP	2.7-3.1	22	1.25	4.5	2.0:1	+23	350
AFD3-031042-23P-SP	3.1-4.2	22	1.25	4.5	2.0:1	+23	350
AFD3-040080-23P-SP	4-8	20	1.25	5.5	2.0:1	+23	350
AFD3-020080-20P-SP	2-8	18	1.50	6.0	2.0:1	+20	350
AFD3-080120-20P-SP	8-12	15	1.50	6.5	2.0:1	+20	350
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**m**icrowave designers must think hierarchically. But their software tools do not often provide the automatically data transfer and linking of tools to support such thinking. Fortunately, the Ansoft Designer software environment from Ansoft Corp. (Pittsburgh, PA) allows RF/microwave engineers to move seamlessly from physics-based electromagnetic (EM) models, to detailed voltage and current-

edge-based solution management ensures that data is maintained across levels, that solved data is instantly available at

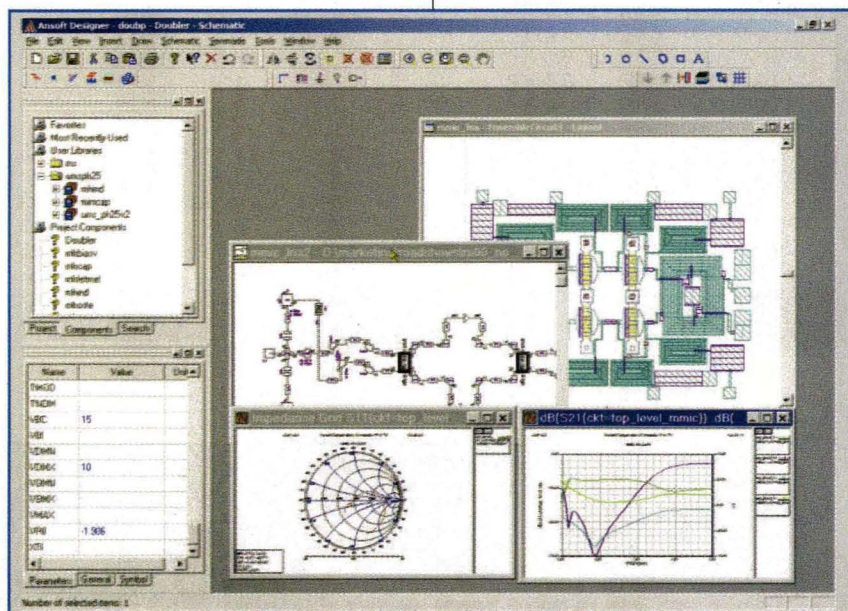
all levels, and that simulation is re-invoked only if the data becomes invalid due to user modifications.

Ansoft Designer features advanced design entry and data management,

## DAVID VYE

Product Marketing Manager  
Ansoft Designer™

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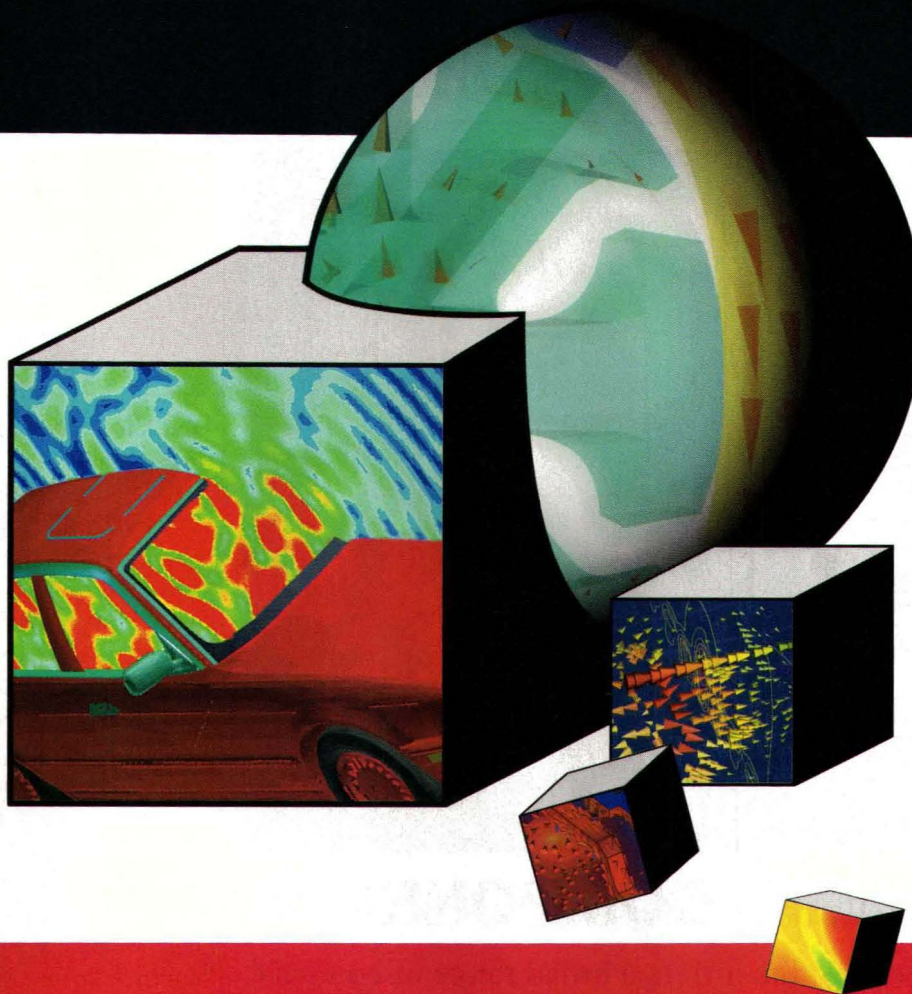


Ansoft Designer can seamlessly switch between schematic capture and layout editors, allowing users to enter data and components from either screen.

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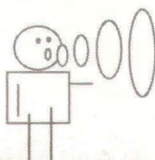
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with fully linked schematic and layout editors. The circuit, system, and EM solvers all employ the same linear circuit components. Because linear components can be embedded in either an EM simulation, in a circuit simulation, or in a system simulation, engineers can

simultaneously design for electrical performance and layout considerations.

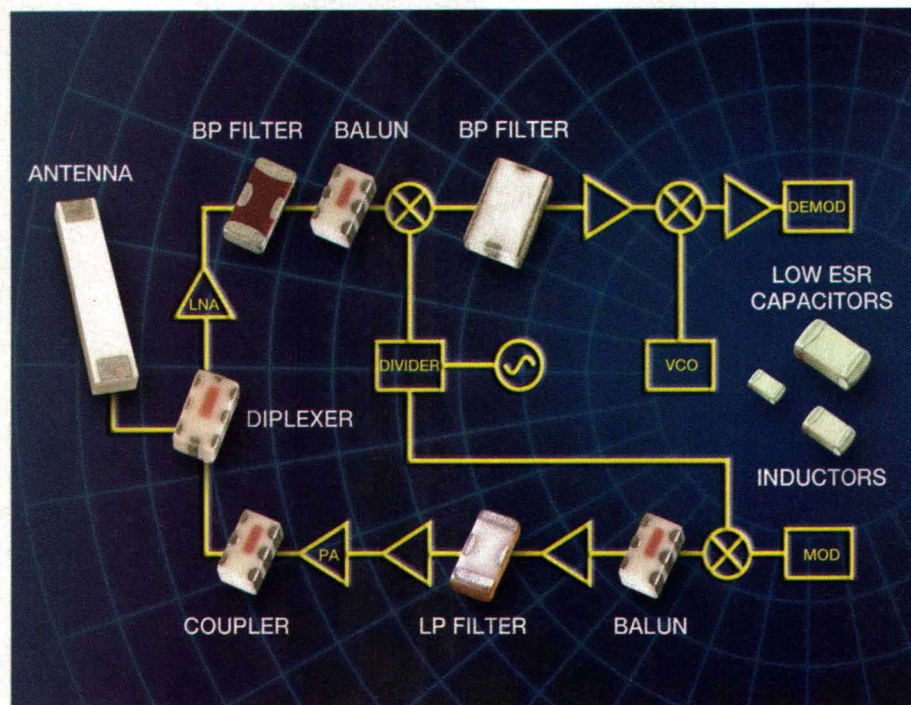
For example, a component can be represented by a layout symbol in the layout editor or as an electrical symbol in the schematic editor (see figure). A system or subsystem block diagram can be

developed with actual physical interconnects for simulation and real-estate planning. System-level behavioral models can be associated with footprints (fixed, parameterized, or scripted) to support viewing in the layout editor. Ansoft Designer automatically connects electrical and physical models so that entries made in one view are translated into the other view, allowing component parameters to be edited from either view. This capability of moving back and forth between schematic and layout screens allows designers to quickly develop complex devices, such as multichip modules (MCMs). A powerful three dimensional (3D) viewer with rotate-and slice-view capabilities provides indispensable visualization for multilayer circuit construction.

Electrical elements that have no physical counterparts, such as RF ports and parasitic capacitances, can also be placed directly into a layout and are represented by the element symbol. Ansoft Designer allows users to create their own specialized models by defining the current-voltage, charge-voltage, and noise equations for a generic component. These user-defined models can be created right in the schematic diagram without having to write and compile code separately. To simplify archiving, complex systems that consist of multiple layouts or schematic drawings are saved as a single open-architecture ASCII file.

Ansoft Designer combines time-domain, frequency-domain, and system-level analysis tools to perform multiple simulations on devices, circuits, and/or systems. Ansoft Designer provides system and circuit-level simulation, method-of-moments (MOM) 3D planar EM simulation, and integration with the company's 3D full-wave finite-element EM simulator, High-Frequency Structure Simulator (HFSS).

The system simulation capability within Ansoft Designer provides time-domain, frequency-domain, and mixed-mode analysis for arbitrary system topologies. It also allows operators to simulate a wide range of communications-system performance parameters, including



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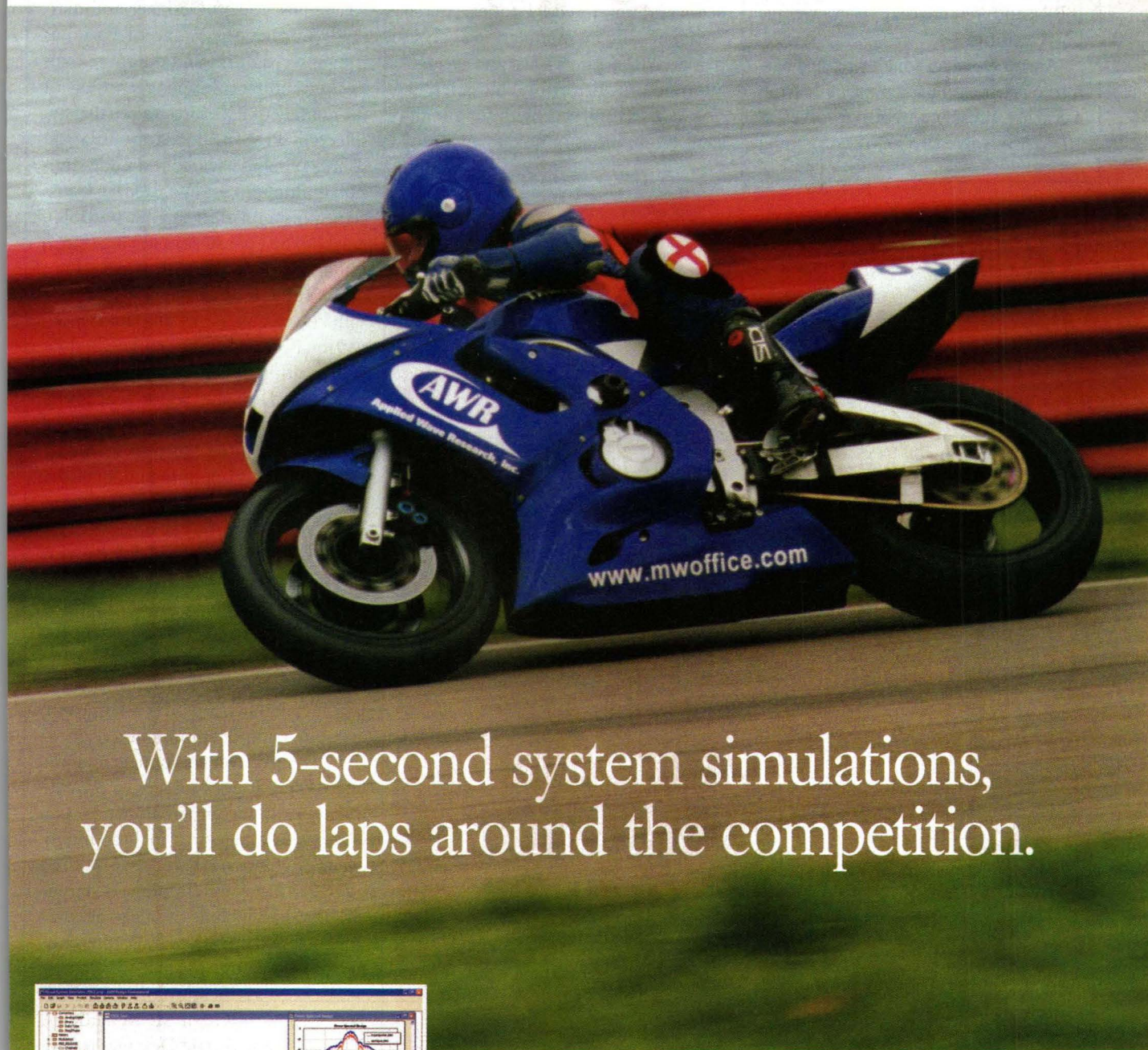
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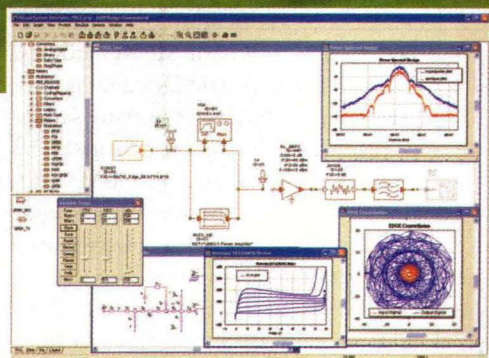


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adjacent-channel power, bit-error rate (BER), and crest factor (peak-to-average power ratio).

Ansoft Designer's highly refined harmonic-balance-simulation engine employs a Krylov subspace iterative solver to efficiently solve problems containing

large numbers of nonlinear components and unlimited RF tones. Ansoft Designer's digital modulation analysis (FastACPR™) offers a fast and accurate approach to distortion characterization and spectral regrowth for circuits such as amplifiers or mixers operating

with analog and digitally modulated RF signals. Ansoft Designer automatically applies the range of voltages encountered during modulation analysis, providing solutions regardless of the number of RF source values that are selected. Preconfigured modulation sources include wideband code-division multiple access (WCDMA), Gaussian minimum-shift keying (GMSK),  $\pi/4$ -DQPSK, phase-shift keying (PSK), Enhanced Data rates for Global Evolution (EDGE), quadrature amplitude shift keying/quadrature amplitude modulation (QASK/QAM), and code-division multiple access (CDMA).

Ansoft Designer features accurate noise analysis, simulating the spectral distribution of the noise power delivered by circuits operating under either small-signal or large-signal conditions. The load- and source-pull-analysis capability allows engineers to examine all performance criteria as a function of terminating impedance (at fundamental and harmonic frequencies) to determine the optimum-matching strategy.

Ansoft Designer's planar EM simulation capability provides integration, accurate component models, verification, detailed level-component analysis and design. It goes further to provide a seamlessly-integrated ability for circuit-level designers to include highly accurate component models, as well as consider parasitic coupling of larger circuits. This includes models for components such as vias, spirals, interconnects, filters, and patch antennas, as well as EM verification of entire integrated circuits (ICs) or MCM modules.

In addition, Ansoft Designer is integrated with HFSS, the company's highly regarded 3D EM simulator. HFSS extends Ansoft Designer's EM functionality by providing analysis capabilities for arbitrary 3D geometry shapes and material variations. A broad class of analysis and optimization algorithms address many aspects of circuit or component performance, such as circuit parameters, parasitic coupling, resonances, and radiation effects. An automated adaptive refinement algorithm provides accurate predictions, and advanced



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post-processing techniques are available to "look inside" components.

Ansoft Designer also embraces Full-Wave SPICE, a proprietary technology that provides efficient analytical transformations between EM and circuit levels. Full-Wave SPICE uses reduced-order models of the dominant poles and zeros of the EM system to provide broadband fast-frequency sweeps and rapid detailed transient waveforms at the circuit level.

The new transient-analysis capability in Ansoft Designer is useful for simulating oscillator start up and amplifiers under power-up conditions. The transient analysis tool includes an embedded convolution engine to handle frequency-domain models or scattering (S)-parameter data files. Ansoft Designer also contains a modulation-based harmonic-balance simulator (a circuit-envelope simulator) for analyzing designs with complex waveforms. The software suite includes a variety of waveform models developing according to accepted communications standards, such as WCDMA, cdma2000, time-division-synchronous CDMA (TD-SCDMA), HiperLAN/2, IEEE 802.11a/b, Global System for Mobile Communications (GSM), and EDGE.

Ansoft Designer's ability to automate hierarchical data structures and multilevel solutions greatly improves design and test productivity. Designers can create parameterized subcircuits at all levels, and then integrate these subcircuits as part of larger designs. This allows engineering teams to work efficiently with segmented design tasks. Ansoft Designer supports a PSpice<sup>®</sup> netlist syntax that will accommodate the direct use of many existing Simulation Program with Integrated Circuit Emphasis (SPICE) libraries. Ansoft has also developed links into the most commonly employed computer-aided-design (CAD) tools through the AnsoftLinks interface. The Ansoft Neutral file format supports Ansoft developed translators to and from IC and printed-circuit-board (PCB) electronic-design automation (EDA) such as Virtuoso and Allegro from

Cadence Design Systems and Board Station from Mentor Graphics.

Ansoft Designer has been developed for personal computers (PCs) and UNIX workstations. It is designed for use with most leading operating systems, including Windows NT 4.0 (SP6 or higher ver-

sion) and 2000 Professional (SP2 or higher version). Ansoft Corp., 4 Station Square, Suite 200, Pittsburgh, PA 15219; (412) 261-3200, e-mail: [information@ansoft.com](mailto:information@ansoft.com), Internet: [www.ansoft.com](http://www.ansoft.com).

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# Splitters/Couplers Distribute In-Building Wireless Signals

These components help bring signals from wireless carriers to targeted areas of high-rise office buildings through coaxial-cable distributed antenna systems.

**I**n-building cellular coverage offers unique challenges for network installers. Signals must be distributed evenly throughout a building, with minimum loss and phase distortion. Three techniques are commonly used for in-building wireless signal distribution: optical fiber, repeaters, and coaxial cable. Of the three, coaxial cable is generally the easiest and least costly to deploy, as well as being quite

The D2-55FN two-way splitter evenly splits input signals between 700 MHz and 2.7 GHz into two outputs,

each with DC continuity. The ability to deliver DC power on the same cable as the RF signals allows other components in the system to be powered without additional wiring. Loss is typically below 0.1 dB. The DK-34FD unequal power splitter distributes input signals between 800 MHz and 2.2 GHz into two outputs in a 2:1 ratio with DC continuity to main and branch lines.

reliable. To meet the needs of coaxial-based, in-building, wireless distributed-antenna systems, Microlab/FXR (Livingston, NJ) has designed a range of couplers and splitters with low insertion loss, broadband frequency coverage, low passive-intermodulation (PIM) distortion, and high reliability.

Compared to their optical and wireless repeater counterparts, coaxial-cable distributed-antenna systems are low in cost and inexpensive to maintain. As in-building systems evolve, there is a trend toward distribution of the signals from multiple carriers, known as neutral hosting. To support neutral hosting, Microlab's in-building wireless line include equal-power splitters, unequal power splitters, and 3-dB hybrid couplers. Each is very low-loss, has PIM specified to below  $-140$  dBc, is moisture sealed, has few solder joints, and has no resistors to burn out to ensure high reliability. The components are configured to be mounted flush with a wall or post, and can be specified with either Type N or 7-16 mm DIN connectors.

The CA-44D 3-dB hybrid coupler combines the signals of two wireless carriers operating between 800 MHz and 2.2 GHz into a single output and handles 120-W average input power. When two similar feeds are required (such as on two floors of an office building), both outputs of the CA-44D can be used, which eliminates the 3-dB loss of the device, as well as the need for the termination used in the single-output situation. Microlab/FXR, 10 Microlab Rd., Livingston, NJ 07039-1682; (973) 992-7700, FAX: (973) 992-0513, e-mail: sales@microlab.fxr.com, Internet: microlab.fxr.com.

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# Bluetooth Components Target Embedded Solutions

These second-generation chips help designers cut power, size, and cost from their embedded Bluetooth designs for personal computers and cellular telephones.

**b**luetooth has received an enormous amount of attention for a wireless standard with so few commercial products currently available. But it is a standard with tremendous potential for market growth, especially as an embedded solution for wireless connectivity for a variety of electronic devices, including cellular telephones and personal digital assistants (PDAs). With these embedded markets in mind,

multiple-access (CDMA) and Global System for Mobile Communications (GSM) handset designs. Each IC

Silicon Wave has developed their second generation of Bluetooth components, including low-cost radio modems and baseband processors. The integrated circuits (ICs) promise savings in operating power compared to the firm's first-generation devices.

These second-generation devices save space and power compared to the firm's earlier Bluetooth offerings. Compared to the company's first-generation products, the new radio modems and baseband processors decrease power consumption by up to 90 percent, system cost by 30 percent, and size by 60 percent.

The new SiW1701, SiW1702, and SiW1703 radio modem ICs employ the same 0.35- $\mu$ m bipolar-complementary-metal-oxide-semiconductor (BiCMOS) technology as the company's earlier SiW1502 radio modem, but with circuit refinements meant to reduce power consumption and size. The SiW1701 is a general-purpose radio IC, while the SiW1702 and SiW1703 ICs are optimized for compatibility with code-division-

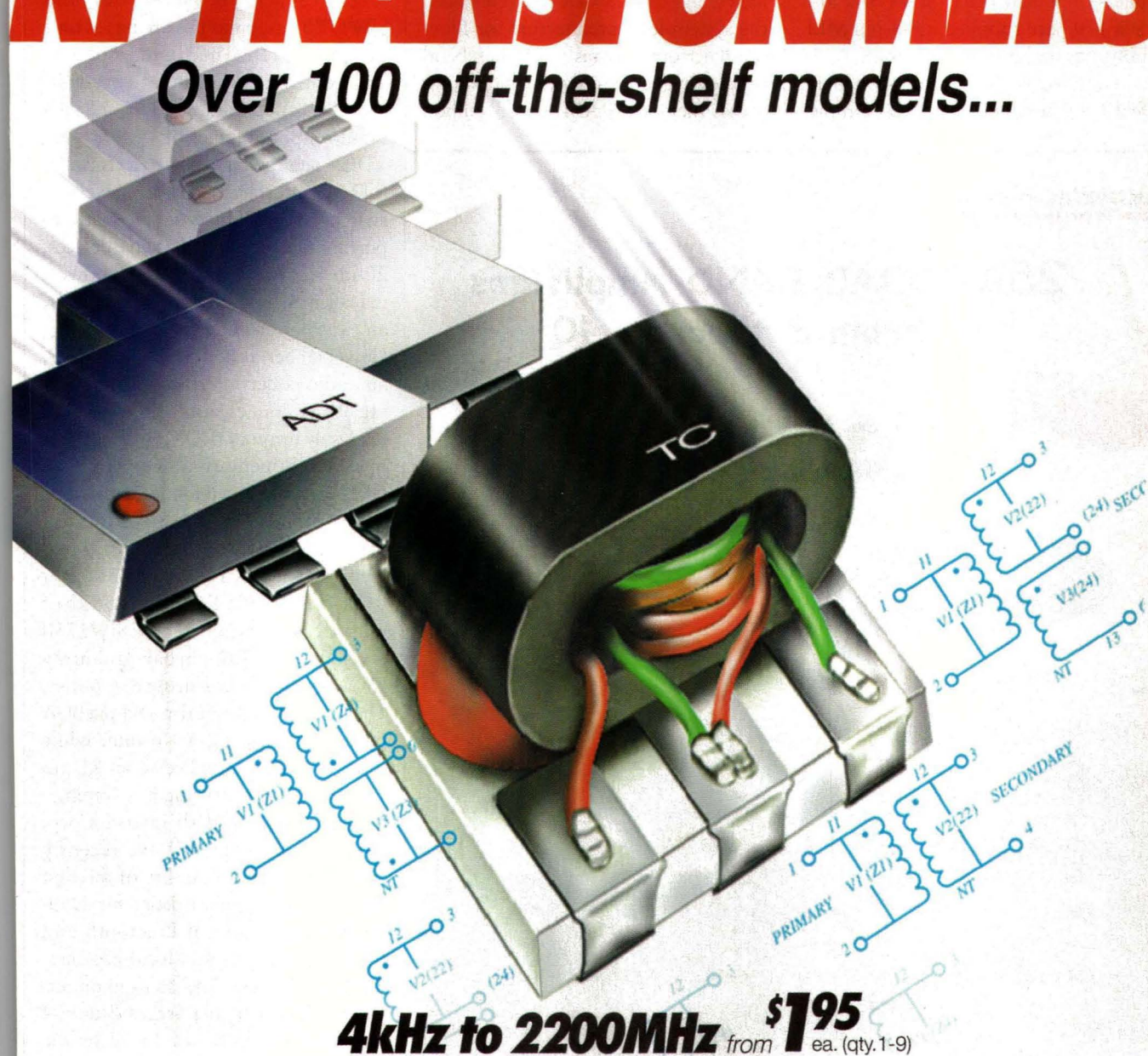
includes a single-ended low-noise amplifier (LNA) and frequency downconverter, a single-ended driver amplifier and frequency upconverter, a Gaussian frequency-shift-keying (GFSK) demodulator and modulator, and programming and control circuitry. The radio modems can meet Bluetooth specification 1.1 requirements for Class 2 (when using output-power control) and Class 3 transmit power levels (+4 and 0 dBm, respectively) and can achieve Class 1 transmit power with an external power amplifier (PA).

The radio modems feature a direct-conversion architecture that does not require an external channel filter or voltage-controlled-oscillator (VCO) resonator components. Since the radio modems incorporate voltage regulation, external voltage regulators are not needed. The radio modems can work with supply voltages of +3.0 to +5.2 VDC, and support multiple crystal reference frequencies, including 12, 13, 32, and 48 MHz. The radio modems are equipped with digital interfaces

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## PRODUCT technology

designed to work with baseband processors from Silicon Wave and other suppliers. The SiW1701, SiW1702, and SiW1703 are supplied in 48-pin MLF housings measuring  $7 \times 7$  mm.

For lower power consumption in the SiW1700 series, Silicon Wave imple-

mented the baseband ICs in 0.18- $\mu$ m CMOS technology, lowered the internal voltage to +1.8 VDC, and enhanced the system-level architecture for Bluetooth performance tasks. The baseband processors require only 12-kb random-access memory (RAM) and 3 million

instructions per second (MIPS) processing power from a host processor.

The SiW1750, SiW1760, and SiW1770 baseband ICs are based on a 32-b ARM7TDMI microprocessor core. The controllers operate at core voltages from +1.62 to +1.98 VDC, and with input/output voltages of +1.8 or +3.3 VDC. Each baseband controller includes a JTAG interface, a master/slave role switch with full Bluetooth piconet support for one master and 7 slave devices, 20-kb of static RAM (SRAM), power-management and sleep-mode controller, an external-bus interface unit (EBIU), Universal Serial Bus (USB) controller, an audio codec interface for connecting PCM codecs, and internal boot read-only memory (ROM) with support from Flash memory downloads. The SiW1750 is designed for use with external Flash memory. The SiW1760 and SiW1770 feature on-board integrated memory, the SiW1760 with 256 kb of ROM and the SiW1770 with 256 kb of internal Flash memory. The SiW1750 is supplied in a 132-pin ball-grid-array (BGA) package measuring  $6 \times 6$  mm. The SiW1760 is supplied in a 64-pin BGA package measuring  $6 \times 6$  mm, while the SiW1770 is supplied in an 81-pin BGA housing measuring  $8 \times 8$  mm.

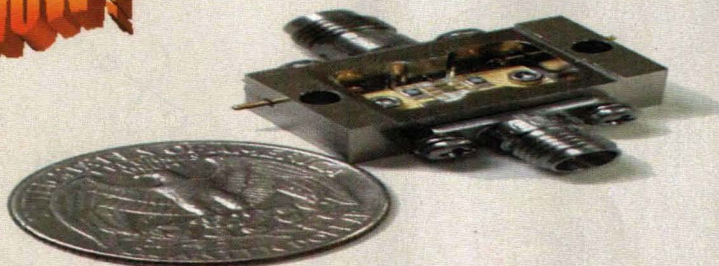
In partnership with Intersil Corp. (Irvine, CA), Silicon Wave recently announced the availability of the first mini-PCI card reference design for simultaneous operation of Bluetooth and IEEE 802.11b wireless local-area networks (WLANs). The dual-mode reference design incorporates Blue802 technology (jointly developed by the two companies) and is based on Silicon Wave's SiW1700 series ICs, as well as Intersil's PRISM 3 WLAN chips.

All of the new SiW1700 series ICs are compatible with the company's first-generation radio modems and link manager. P&A: \$5 each (SiW1701/1702/1703 and SiW1750/1760, 100,000 qty.) and \$6.95 (SiW1770, 100,000 qty); stock. Silicon Wave, 6256 Greenwich Dr., Suite 400, San Diego, CA 92122; (858) 453-9100, FAX: (959) 453-3332, Internet: [www.siliconwave.com](http://www.siliconwave.com).

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NB00378	26 - 40	21	1.9:1	19	21

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This family of integrated SiGe transmit mixers provides high performance, reduced cost, and small size for cellular base-station transceiver systems.

**a**ctive mixers have rarely been associated with cellular base transceiver stations due to their traditionally limited linearity. But the STM family of active transmit mixers from Sirenza Microdevices (Sunnyvale, CA) provide the linearity associated with passive diode mixers at a fraction of the cost and size. The three new STM family transmit mixers leverage ever-improving silicon-germanium (SiGe) technology to

communications-services (PCS), digital-communications-services (DCS), and Universal Mobile Telecommunications System (UMTS) base-station-transceiver-station (BTS) applications.

The STM transmit mixer integrated-circuit (IC) architecture consists of a Gilbert cell mixer, an IF amplifier, RF amplifier, and LO buffer amplifier. The entire architecture is implemented in a balanced configuration,

provide signal-conversion gain with high output third-order intercept points (IP3s), while working with low local-oscillator (LO) drive levels (typically 0 dBm). The mixers achieve low LO-RF leakage, while providing high-performance intermediate-frequency (IF) to RF conversion for Global System for Mobile Communications (GSM), personal-

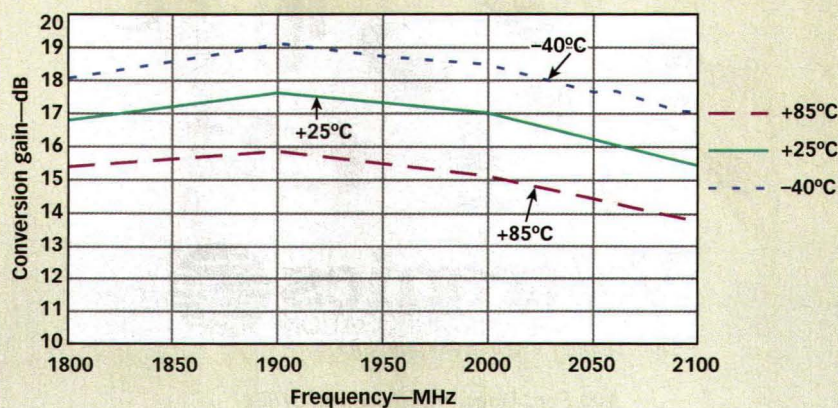
## THOMAS CAMERON

Director of Marketing, Wireless Products

## GREG BABCOCK

Design Engineer

Sirenza Microdevices, Inc., 522 Almanor Ave., Sunnyvale, CA 94086; (800) 764-6642, (408) 616-5400, FAX: (408) 739-0970, Internet: [www.sirenza.com](http://www.sirenza.com).

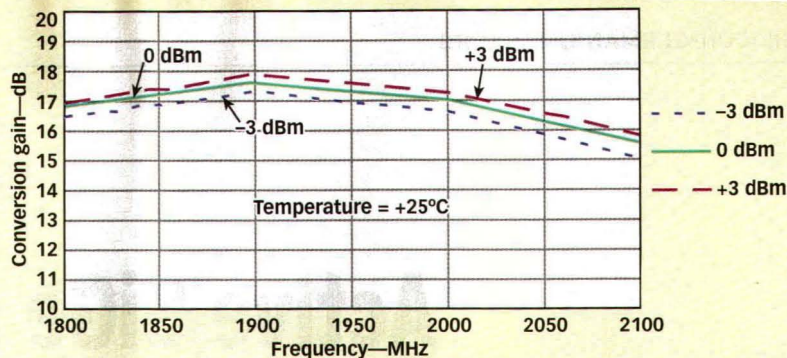


1. The conversion gain of the STM-2116 was measured as a function of frequency at three different operating temperatures.

## PRODUCT technology

resulting in improved linearity and spurious suppression. Each STM mixer is fully integrated on a single SiGe die and packaged in a standard TSSOP16 plastic package with an exposed ground pad.

These integrated mixers offer sev-



2. The conversion gain of the STM-2116 was measured at room temperature (+25°C) for three different LO drive levels.

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eral advantages to system designers. All amplifiers are included within the package, unlike discrete upconverter implementations, resulting in a substantial savings in circuit-board space. A discrete passive-mixer approach requires amplifiers on at least two of the three ports to achieve the high LO drive and compensate for the conversion loss of the mixer, adding to the cost, size, and complexity of a BTS design.

All three mixers operate with IF signals from 30 to 400 MHz and with LO levels of 0 dBm. Model STM-1116 provides RF signals from 800 to 1000 MHz. Model STM 2116 yields RF signals from 1800 to 2100 MHz and model STM-3116 produces RF output signals from 2100 to 2500 MHz. The conversion gain is 13 dB for the lower-frequency unit and 17 dB for the two higher-frequency mixers. The output power at 1-dB compression is +8 dBm for the lower-frequency model and +11 dBm for the two higher-frequency units. The single-sideband (SSB) noise figure is typically 9 dB for all models. The output IP3 for the STM-1116 is +22 dBm, and +24 dBm or better for the other two mixers. The LO-to-RF leakage is better than -20 dB for all models, while the LO-to-IF leakage is better than 30 dB for all models. The mixers draw 200 mA from a +5-VDC supply. All three mixers are physically identical, with a common TSSOP16 package and pin-out, with broadband RF and LO ports impedance matched to 50 Ω.

The conversion gain of the STM-2116 was measured over frequency for three different operating temperatures (Fig. 1). On-chip inductors that maximize

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Gali □ 21	DC-8000	14.3 13.1	±0.6	12.6	4.0 27	128	40	3.5	.99
Gali □ 2	DC-8000	16.2 14.8	±0.7	12.9	4.6 27	101	40	3.5	.99
Gali □ 33	DC-4000	19.3 17.5	±0.9	13.4	3.9 28	110	40	4.3	.99
Gali □ 3	DC-3000	22.4 19.1	±1.7	12.5	3.5 25	127	35	3.3	.99
● Gali □ 6F	DC-4000	12.1 11.6	±0.3	15.8	4.5 35.5	93	50	4.8	1.29
● Gali □ 4F	DC-4000	14.3 13.4	±0.5	15.3	4.0 32	93	50	4.4	1.29
● Gali □ 51F	DC-4000	18.0 15.9	±1.0	15.9	3.5 32	78	50	4.4	1.29
● Gali □ 5F	DC-4000	20.4 17.4	±1.5	15.7	3.5 31.5	103	50	4.3	1.29
● Gali □ 55	DC-4000	21.9 18.5	±1.7	15.0	3.3 28.5	100	50	4.3	1.29
● Gali □ 52	DC-2000	22.9 17.8	±2.5	15.5	2.7 32	85	50	4.4	1.29
● Gali □ S66	DC-3000	22 17.3	±2.4	2.8	2.7 18	136	16	3.5	.99
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Gali □ 51	DC-4000	18.1 16.1	±1.0	18.0	3.5 35	78	65	4.5	1.49
Gali □ 5	DC-4000	20.6 17.5	±1.6	18.0	3.5 35	103	65	4.4	1.49

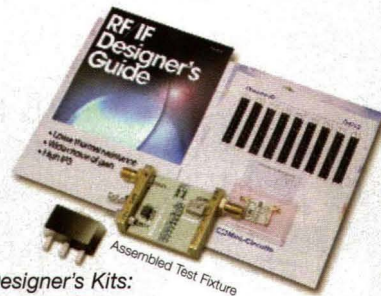
■ Low frequency cutoff determined by external coupling capacitors. † Measured in test fixture P/N 90-6-20-26.

▲ Models tested at 2GHz except Gali □ 4, 5, 6, 51, 52, 6F, 4F, 51F, 5F at 1GHz.

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the gain and linearity of the output amplifier set the response of the mixer, with frequency response well-behaved from 1800 to 2100 MHz. The total gain variation is approximately 0.5 dB in either the PCS or DCS band, while the gain variation at any single fre-

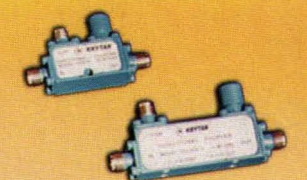
quency is 3 dB when the ambient temperature is varied from  $-40$  to  $+85^{\circ}\text{C}$ . Although the mixer is optimized for the DCS and PCS bands, it is usable outside those ranges with degraded performance. The responses of the STM-1116 and STM-3116 are very similar,

in their respective frequency ranges.

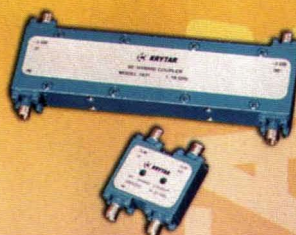
The conversion gain of the STM-2116 is stable with different LO drive levels, due to the on-chip saturated LO buffer. The total variation in conversion gain for LO drive levels from  $-3$  to  $+3$  dBm is less than 1 dB at any frequency in the range (Fig. 2).

The active mixer designs offer outstanding LO-to-RF isolation (20 to 30 dB) and LO-to-IF isolation (30 to 45 dB). LO-RF leakage is a key specification for a transmit mixer, since it influences the system frequency plan. For example, the linear RF output level of the STM-2116 is approxi-

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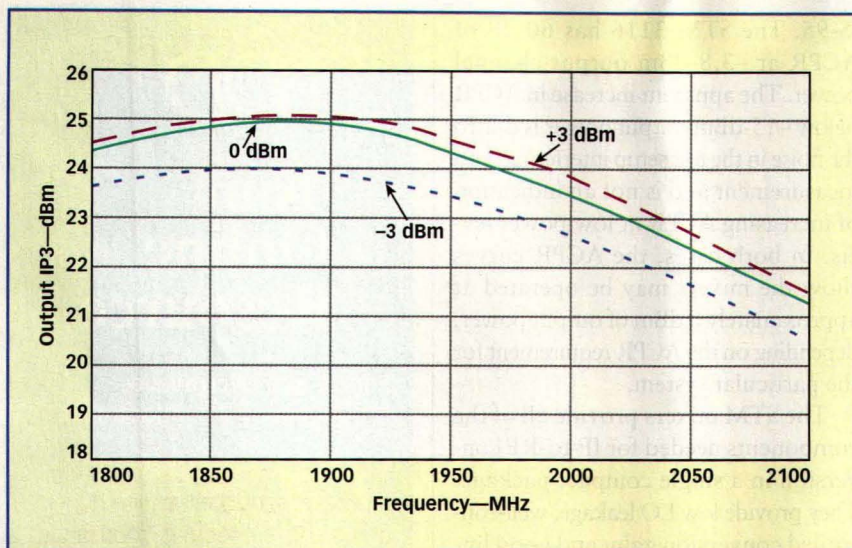
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mately 0 dBm and the LO signal present at the RF port is at  $-20$  dBm. In a passive implementation with a high LO ( $+17$  to  $+19$  dBm), the linear output level is approximately the same level (0 dBm), but the LO signal present at the RF port may also be 0 dBm or higher. In this case the frequency plan must be selected so that the LO is sufficiently suppressed by the RF filter. STM mixers provide at least 20 dB of LO suppression, reducing RF filter requirement and allowing greater flexibility in the frequency plan. Additionally, the low level of LO harmonics produced in the RF output may also have advantages in GSM systems where spurious signal suppression is always a challenge.

Figure 3 shows the STM-2116's output IP3 as a function of frequency and LO drive. At any particular frequency,

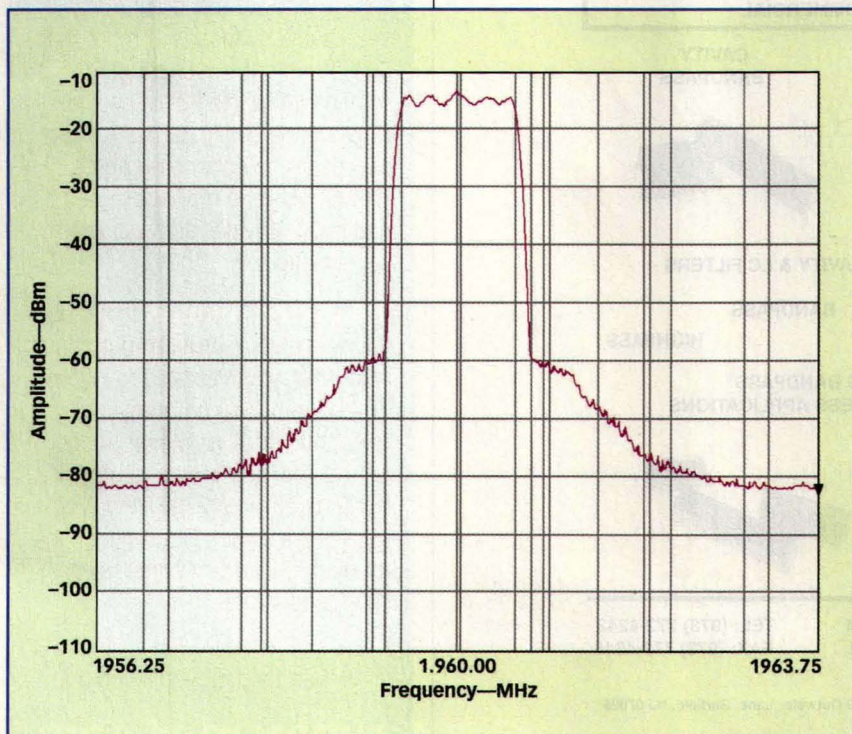
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3. The output IP3 of the STM-2116 was measured as a function of frequency at three different LO drive levels.

the output IP3 varies approximately 1 dB over the LO range of -3 to +3 dBm. In addition, the third-order-intercept variation over frequency is well-behaved. In the DCS band, the output IP3 at 0-dBm LO power varies by less than 0.5 dB. Over the PCS band, the output third-order intercept varies by approximately 1 dB. The third-order-intercept

performance of the STM mixers is generally much more tightly distributed and predictable as a function of LO power than field-effect transistor (FET) or diode mixers. As an example, a typical diode mixer module may exhibit up to 3-dB variation over the LO range compared to 1-dB variation for the STM mixers.



4. The ACPR performance of the STM-2116 was evaluated using an IS-95 signal in the PCS band at 1960 MHz.

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The performance shown so far indicates good mixer performance with narrowband modulation. For wideband modulation formats such as code-division multiple access (CDMA) and wideband CDMA (WCDMA), the adjacent-channel-power ratio (ACPR) is a better figure of merit. **Figure 4** shows the ACPR spectral measurement for the STM-2116 using an IS-95 signal in the PCS1900 band centered at 1960 MHz. With average-channel output power of 0 dBm, the measured upper ACPR is 61.26 dB, while the lower ACPR is 60.68 dB. **Figure 5** shows the ACPR curves over average-channel output power for the STM-2116 and the STM-3116. The STM-2116 was evaluated using an IS-95 signal at 1960 MHz, while the STM-3116 was measured using a Third Generation Partnership Project (3GPP) WCDMA signal in the UMTS band at 2140 MHz. As expected, the WCDMA ACPR is lower than

IS-95. The STM-3116 has 60 dB of ACPR at -3.8-dBm output-channel power. The apparent increase in ACPR below -15-dBm output power is due to the noise in the test setup interfering with measurement and is not an indication of increasing ACPR at low power levels. In both cases, the ACPR curves show the mixers may be operated at approximately 0 dBm of output power, depending on the ACPR requirement for the particular system.

The STM mixers provide all of the components needed for IF-to-RF conversion in a single compact package. They provide low LO leakage, well-controlled conversion gain, and good linearity to simplify BTS designs. **Sirenza Microdevices, Inc.**, 522 Almanor Ave., Sunnyvale, CA 94086; (800) 764-6642, (408) 616-5400, FAX: (408) 739-0970, Internet: [www.sirenza.com](http://www.sirenza.com).

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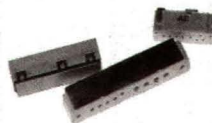
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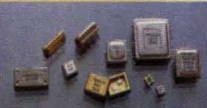
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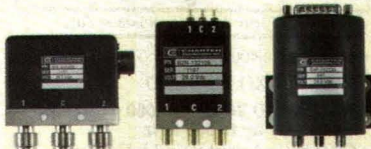
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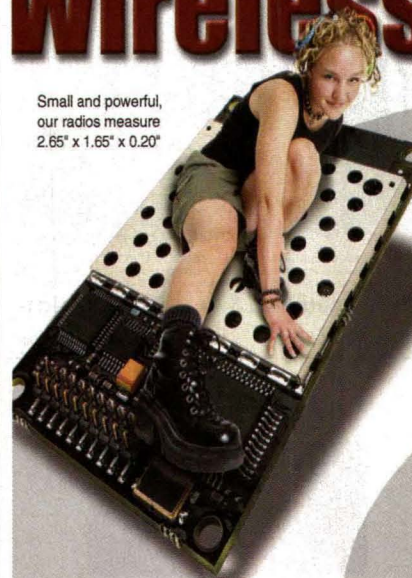
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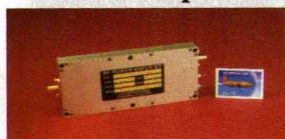
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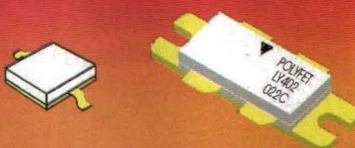
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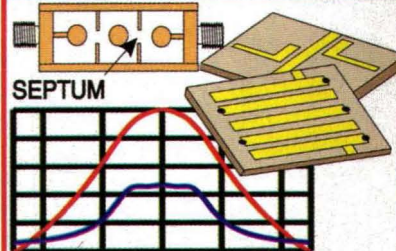
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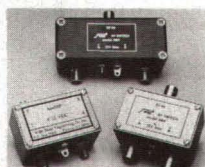


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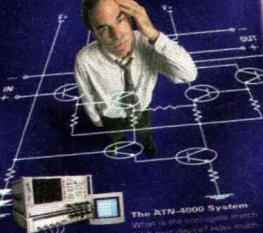
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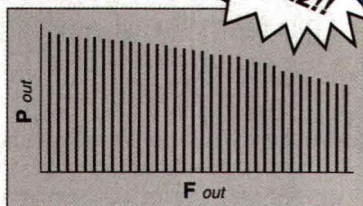
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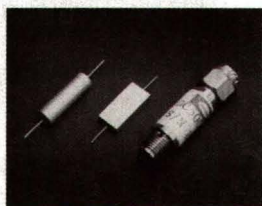
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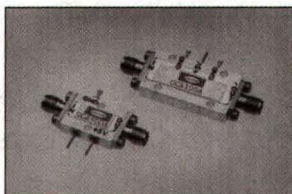


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## next month

### Microwaves & RF July Editorial Preview Issue Theme: Frequency Generation

#### News

The July issue will offer a special Technology Report on the state of high-frequency signal generation, notably vector-signal generators used in the testing and analysis of modern communications systems. Vector-signal generators produce modulated signals with in-phase and quadrature modulation components. In recent years, the trend has been to offer increasing I/Q modulation bandwidths in support of the increasing information bandwidths of wireless systems. The report will sample the latest test-signal generators from a variety of suppliers and compare some of the key features in terms of signal purity and frequency accuracy.

demonstrates their impact on wireless radio designs. Additional technical articles in July include the conclusion of a two-part article on biasing techniques for improved linearity in RF PAs; Part 5 of an article series on short-range radios, with emphasis this month on the basics of loop antennas; and Part 2 of an article series from Maxim on the design of high-performance LNAs.

#### Product Technology

The July Product Technology section features a close look at permanent-magnet YIG oscillator technology and how refinements in these frequency-generating devices are improving the performance of point-to-point digital microwave radios. Additional product stories will unveil a wideband VNA system that works with modulated test signals; the industry's first commercial UWB radio chip set capable of wireless transmission of 100 Mb/s data rates with only 200 mW of power; and a novel, low-cost chip set for HomePlug applications—transmitting data rates past 13 Mb/s over AC power lines.

#### Design Features

The Design Features section in July kicks off with a comprehensive review of changes that have occurred in VCO technologies over recent years. The author, a Member of the Technical Staff of Maxim Integrated Products, traces these technology changes over the last decade and

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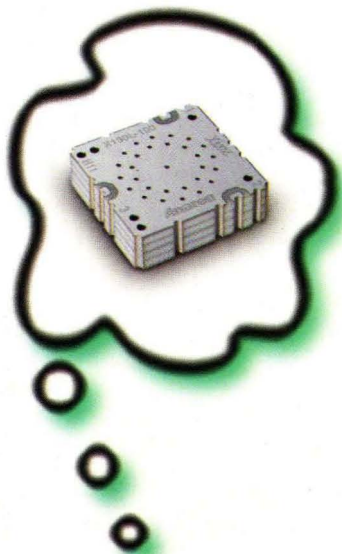
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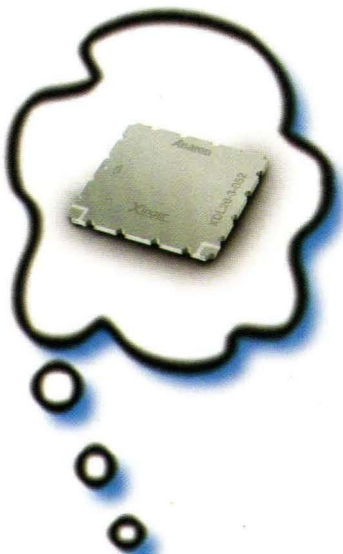
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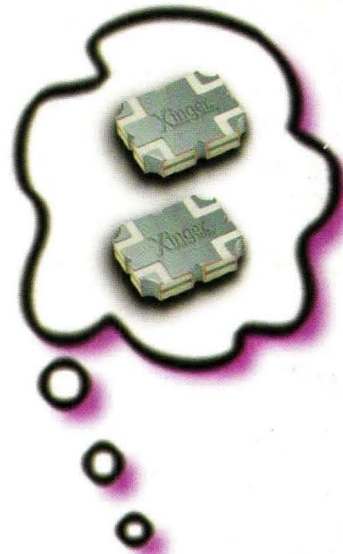
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